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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1952 [1]

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STATION RESEARCH IN REVIEW

Farmers and the general public are showing an increasing awareness of the significance and scope of agricultural research as carried on in this country by the State agricultural experiment stations and the United States Department of Agriculture. These public agencies, working in close cooperation with each other and with industry and numerous other national, State, and local groups, are making a major contribution to a progressively expanding national economy.

The possibilities offered as a result of this research were highlighted in June 1952 in the report of a cooperative study made under the auspices of the Land-Grant College—Department of Agriculture Joint Committee on Agricultural Productive Capacity.

An appraisal was made in each State by a technical committee appointed by the State experiment station director for the purpose of estimating the production levels that farmers could attain within the next 4 or 5 years under specified high-level production conditions. If these prevailed and if improved present-day practices were used, the study indicated a possible national farm output in 1955 about 20 percent greater than in 1950 and 18 percent greater than in 1951.

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1952.

The unprecedented ability of the American farmer to produce agricultural commodities is an example of the rapid industrialization of this country and its high standard of living. The United States has emerged from a land predominantly rural to a highly industrialized nation. The farm population in 1951 accounted for only 15.1 percent of the total population, yet the farmers produced sufficient agricultural products to supply the needs of the domestic population of this country and in addition huge quantities for export. The output per man-hour on the farm in 1951 was 45 percent above that of 1940 and 86 percent above that of 1930.

There is every indication that greater improvements in our standard of living in the future, as in the past, will depend largely upon a greater degree of farm efficiency and productivity. The principal way to increase food and fiber production for our growing population is to obtain increased yields from land already in production. This will require the continued efforts of scientifically trained agronomists, plant and animal geneticists, plant and animal pathologists, entomologists, farm-management and marketing specialists, chemists, nutritionists, horticulturists, agricultural engineers, and others. Scientists are constantly developing new research techniques that bring about greater precision in scientific observations. Better statistical methods developed from time to time are also making valuable contributions to the field of scientific research. Time-and-motion studies and other industrial engineering procedures, already being used as effective tools in finding ways of accomplishing given tasks efficiently, offer relatively new approaches to agricultural research.

Each year the experiment stations are taxed to the limit of their resources to find solutions for immediately pressing farm problems. In recent years the stations have placed increased emphasis on organized basic research. They have been aided in this by such new tools as the electron microscope and radioactive materials. These have made it possible to probe more deeply into many phenomena of nature, such as the functioning of various organs in the animal body, the mechanism of plant and animal nutrition, and the various chemical and physical interchanges that take place in the different kinds of soil under the management and cropping practices followed by farmers. An increasing number of younger scientists trained in the use of these newer tools and techniques is becoming available to agricultural experiment station staffs.

With the greater emphasis on fundamental research has come a closer integration of staff activity at the respective institutions. In every specialized field of agricultural science there is a growing recognition of the staff concept that knowledge must be shared and efforts pooled to insure the greatest over-all progress. In the integrated studies of fundamental problems relating to agriculture lie the promise of greater things to come in the tomorrow of American agriculture.

AGRICULTURAL ENGINEERING

In this 1952 report the Office of Experiment Stations has singled out for special emphasis, typical representative examples of the rapid advances made in the mechanization of crop production through research at the State agricultural experiment stations. Nowhere can the

practical, operating farmer find more tangible proof that research pays off than in the substitution of mechanical power for human labor and work animals. Since the early days of American history our farmers have sought short cuts to overcome the weariness and drudgery of waste motion. Ever since Thomas Jefferson applied the principles of mathematical science to improve plow moldboards and thereby upset the traditional plowing practice of many centuries, the farmers of America have been interested in the development of mechanical improvements in their tools of production. Thousands of middle-aged farmers today recall the thrill and toil of threshing time in the early 1900's. The threshing machines and steam engines and horse-drawn water tanks of those days were great improvements over the methods used by their fathers when oxen treaded out the grain. Yet threshing devices of 50 years ago were crude mechanical devices compared with the modern combines that today have taken over the job.

Mechanization of Crop Production

Wider adaptation of farm machinery for specialized use has been made along many lines. In 1952, there were 4,170,000 tractors on American farms as compared with 1,545,000 in 1940 and 920,000 in 1930. During the past decade, the number of motortrucks on the farm has more than doubled; the number of grain combines has increased more than three times; and the number of mechanized corn pickers has increased more than four times.

The greatest surge in the mechanization of farm production has come within the past 20 years. During the early 1940's when agricultural income rose to a more favorable level, farmers were better able to make capital investments in modern equipment. This trend toward the use of machinery in carrying on farming operations automatically filled the gap caused by the draining of manpower into the armed services and industry, thus enabling the farmer to produce goods and services so urgently needed. It was accompanied by a well-organized program of plant genetics and breeding to meet the limitations of mechanization and the contingencies of crop failure as a result of damage by inclement weather, insects, and diseases; the discovery of new disease- and insect-controlling chemicals; the development of improved fertilization practices; and the devising of better ways of doing many farm tasks. So effective were these developments that production of feed grains was raised from an average of 88,846,000 tons for 1935–39 to 117,630,000 tons for 1942–46. The total production of eight grains increased from an average yearly production of 114,148,000 tons in the prewar period to 150,969,000 tons during the war period.

Today mechanization of numerous common field crops is well advanced. The use of power implements in seedbed preparation, tillage, and cultivation, and in harvesting the cereal grains, wheat, rice, rye, and buckwheat, and the feed grains, corn, oats, barley, and sorghum, as well as hay and other roughage crops is common practice. Although complete mechanization of cotton production has not been so rapid, advancements have been made which, significantly, combine the result of plant genetics research and mechanization research. The same is true for many vegetable crops. The growing of commer-

cial tree fruits—peaches, cherries, and other deciduous fruit and citrus crops—still requires a greater percentage of hand labor than does the growing of the more common farm crops, but even in this farming activity progress has been made, especially in the development of equipment for the effective application of spray materials and fertilizers.

It is in the realm of the many problems still unsolved that research engineers of the agricultural experiment stations are today most busily engaged. They know that achievement of complete mechanization of agriculture is not only a popular goal of operating farmers but that it is economically sound particularly in view of the rapidly increasing nonfarming population. Since agricultural engineers work closely with farmers, they are aware of farmers' needs for new mechanical devices. They hear about the shortcomings of machinery already in use. From close contact with crop specialists at the stations and with engineers in industry who are responsible for designing farm equipment, station agricultural engineers are called upon to determine basic considerations to be kept in mind by farm equipment manufacturers. Each step taken by experiment station engineers must be based on scientific procedure, just as painstaking and accurate as that followed in chemical or biological research.

Farmers are aware that the mechanization of farm work means a saving in farm labor and that the right kind of mechanized equipment can at times mean the difference between profit or loss in a crop. But in making the capital investment in machinery the farmer has to weigh what he might save over the years in time and labor against the cost of interest, depreciation, and repair; he has to know how many hours of work he will get out of a given machine. In the United States tractors are used an average of only 592 hours annually per farm. For other equipment the average is even lower. There has been a heavy increase in recent years of the custom work with specialized farm machinery hired by farmers. These facts stimulate the imagination and effort of the agricultural engineers at the experiment stations and of the engineers in industry in developing low-cost equipment for practical use on the family-sized farm.

The degree of farm mechanization in the United States today cannot be measured by merely counting the number of tractors and other machines used on these farms. The true test of the impact of mechanization on farm operations in this country is the effectiveness with which machinery is used and the economy of power obtained in its operation. The greatest concern of agricultural engineering research, therefore, is to find new ways of utilizing farm power effectively and economically.

As a result of the investigations in the field of agricultural engineering research carried on from time to time in the State agricultural experiment stations, back-breaking labor on farms is rapidly passing and is being replaced by mechanical devices and procedures that not only save time and labor but also improve the quality and increase the yields of food and fiber products.

Examples of some of the findings made in agricultural engineering research in the various stations and of their application to farm operations are here described.

Once-over tillage saves fuel and labor

Once-over soil preparation that eliminates extra tillage operations has helped cut down seedbed preparation costs while still maintaining crop yields. Tests at the Michigan station show that plowing, light conditioning, and planting performed as a single operation produced as high yields of small grains on soil of good tilth as conventional seedbed preparation that included double-disking and spike-tooth harrowing. The once-over method permits quicker planting and saves motor fuel, since two disking and two harrowing operations are eliminated. Another advantage is that under this method soil has greater water-storage capacity, since tilth is not broken down by excessive tillage operations.

At current rates for custom work, conventional methods of tillage would cost $4 an acre for plowing; $1.50 for disking once; $1.50 for dragging once; and $1.50 for drilling—a total of $8.50 an acre. A typical once-over tillage operation, on the other hand, would cost $4 for plowing and combined tillage operations, and $1.50 for drilling—a total of $5.50 per acre or a saving of $3 an acre over conventional tillage methods.

Another promising implement is the so-called plow combine or once-over tillage device that consists essentially of a standard plow with a plow packer immediately behind, or a standard plow with mulcher. The total horsepower hours per acre for preparation of a seedbed were lowest with the plow and plow packer combination. The plow followed by the revolving packing-type tiller appears to be the most efficient from the standpoint of power and labor requirements. It also gave the highest yields.

A new hitch for rear-mounted tractor tools

An improved hitch for tools that can be mounted on the rear of the tractor has been developed by the Iowa station.

The hitch affects the steering of the plow, making it operate more satisfactorily on curves by stabilizing the width of cut on curves under various soil conditions. The hitch also is so arranged as to carry part of the side-thrust on the tractor. A third feature provides proper suction to the plow for all conditions. With this equipment it is possible to plow 3 inches deep without the plow jumping out of the furrow, and to change to a 10-inch depth of cut and still have plenty of suction to load the rear of the tractor sufficiently so it can pull the plow.

In addition to the plow and the one-way disk the hitch has also been applied to a mounted two-row lister. The lister provides smooth operation around the curves, maintains uniform depth of planting, and insures uniform operation of covering wheels.

Specialized power unit for Everglades farming

Agricultural production in the Florida Everglades requires a very complex program of carefully timed spraying or dusting operations for control of insects, plant diseases, weeds, grasses and, more recently, for application of plant nutrients in liquid form. In an attempt to meet these specialized needs the Florida station formulated a series of basic functional requirements for a new piece of farm equipment known as the Everglades Mule.

This tricycle tractor combines a number of operations and saves much time and labor. Power is obtained from an air-cooled engine that drives a single power wheel. The wheel is an independent unit assembly completely detachable through a special pivot-hitch. A U-bolt type of connection permits easy attachment or detachment of two wheeled carts for overtop operation on medium- and high-growing crops. These carts carry supplemental and special equipment such as tanks, booms, quick-coupling hose connection and nozzles, power-driven pumps and dusters, and other pieces of equipment for crop-treating operations. If desired, low-type carts may be attached for miscellaneous hauling chores on the farm.

Mechanization in cranberry production

Agricultural engineers of the Massachusetts station have converted a small tractor with modified wheel equipment into a satisfactory source of power for bog operations at the Cranberry Substation at East Wareham. Spraying and dusting equipment modified for tractor mounting have been added. Because there was a need for mechanizing the operations involved in cleaning and maintaining marginal and field ditches, a ditch-cleaning device to be used on the tractor was also designed. The ditch cleaner consists essentially of a beater, driven by auxiliary power, placed ahead of a dredge snout that is connected to the suction line of a trash pump. The complete device mounts on the tractor, which furnishes the power for the trash pump. The waste is sprayed either on the bog or on the adjacent shore. Traveling at 1½ miles per hour, this machine cleans as much ditch every 5 minutes as one man cleans with a shovel in a day.

About ½ inch of sand is added to the surface of the cranberry bog every 4 years. Although improvements in cultural practices eventually may eliminate the need for sanding, it is considered at present to be necessary since the sand covers the trash and helps prune the vines. Nine men hauling with wheelbarrows and spreading with shovels require 8 hours to cover 1 acre with 60 to 80 cubic yards of sand. An hydraulic sander that handles the sand by a method similar to that followed in water-filtration plants has been developed. Sand from a bin is introduced into the main distribution line by a jet of water and is distributed on the bog by a crew handling smaller hoses fed from the main line. The rate of sand application varies with the length of the main line—from 20 cubic yards per hour at 400 feet of main line to 30 cubic yards per hour at 100 feet. With the new equipment a five-man crew will average 1 acre every 3 hours.

Anhydrous fertilizer placement

Because large amounts of nitrogen fertilizers are needed in the Tung Belt, the Mississippi station was called upon to develop special mechanical means for the proper placement and sealing of anhydrous ammonia in the soil.

Anhydrous ammonia application is complicated in tung orchards by the large amount of trash that lies on the surface of the soil and the large numbers of roots branching out under the surface. The station developed a machine with a disk coulter that cuts through the trash. Other features of this machine are the four field-cultivator springs that trip and reset the applicator, the wings on the bottom of

the applicator to increase the ammonia-absorbing volume of soil, and a gage depth-control wheel that also packs the soil behind the applicator and thus seals the furrow. This new equipment proved satisfactory where the rate of application of ammonia per linear foot is high, the surface of the ground is covered with trash, and there are numerous roots in the soil.

Nematode control by fumigation

Agricultural research is gradually building a supply of reliable information about nematodes, the species of minute parasitic roundworms that affect man, animals, and plant life. In recent years their destructiveness to certain crops has become recognized. A satisfactory method of controlling nematode infestation is through the fumigation of the soil with chemicals. The Georgia station has built a machine with which these chemicals can be applied and that can be attached to any plow. It is driven by a traction wheel, the ground wheel drive eliminating variation in drive speed and thus permitting accurate control of the amount of fumigant released. The rate of release can be varied easily and quickly by turning a crank. The Georgia model was built primarily for experimental use, but it is adaptable for practical nematode control work.

Pasteurizing soil by flash-flame process

A mobile trailer-type soil pasteurizer has been developed at the New York (Cornell) station, for use by vegetable growers, nurserymen, plant growers, florists, and foresters. The pasteurizer is of particular interest to all who desire to eliminate damping-off, weed seeds, nematodes, insects, and wilt-producing organisms from potting soils, seedbeds, compost piles, and plant-house benches.

The unit is an adaptation of a mobile aggregate heater employed by road repairmen to heat materials for patching asphalt-surfaced roads. It consists of a heated, slightly sloping steel cylinder or drum, hexagonal in cross section, 8 feet long and 20 inches in diameter, which revolves about 40 times a minute. Tumbling soil after being fed into the drum is quickly heated and in a few seconds drops from the discharge end of the drum in a steady stream. A blowtorch mounted at the outlet heats the drum and the soil to the correct pasteurizing temperature.

Higher speed in peanut planting

Extensive research on the relation of plant spacing to yields of peanuts shows that these yields increase with closer stands. The optimum seed spacing for Spanish-type peanuts was found to be 3 inches in 24- to 28-inch rows and for the runner-type peanut 5 inches when planted in 28- to 36-inch rows. But these spacings could not be obtained with the use of the tractor-mounted planters generally available that give speeds exceeding 3 and sometimes 5 miles per hour.

To meet the need for closer spacing the Georgia station developed a new type of planter equipped with a continuous belt, perforated with properly sized holes, which runs through a seed hopper at a 45° slope.

Tests of the model planter show that high efficiencies may be obtained at belt speeds necessary to obtain a 3-inch seed spacing at a

ground speed of 10 miles per hour. Seed damage was less than 1 percent, stands of peanuts were uniform, and there were no significant differences in stand count at different speeds except where rock or hard spot was encountered by the furrow opener. Uniform 3-inch spacing of peanuts was also obtained by the planter in several soils at the rates of 10 miles per hour in straight rows and 3.5 miles per hour in curving hillside rows on rolling land.

The unit was also tried with soybeans where 1-inch spacing was desired. The same belts were used, each hole in the belt picking up three soybeans. At speeds above 4 miles per hour enough scatter in the row was produced to provide a surprisingly uniform 1-inch spacing of soybeans.

Pasture improvement by machinery

The Mississippi station developed a machine that makes it possible to reseed and fertilize pasture sod in one operation. This machine is essentially a heavy-duty grain and fertilizer drill, with special furrow cutter openers that cause very little disturbance as they move through heavy turf growth. Tests conducted by the station showed that with this new equipment it is possible to produce as much winter forage or more than could be produced under the former standard method of seeding and fertilizing grain on a prepared seedbed. The best results were obtained when seed was sown in sod in rows 16 inches apart, the fertilizer being put 1 inch to the side of the seed and 1 inch lower. With the new equipment the sod can be seeded and the fertilizer put down in one trip across the field, thus replacing the four or five operations previously necessary in getting good winter pasture established.

Mechanical weeding of sugar beets

A two- or four-row sugar beet weeding machine that also acts as a cultivator, has been developed by research engineers at the Colorado station (coop. USDA).[2] The machine makes application of a new principle. The action of the machine in "selecting" between weeds and beets is based on the fact that beet roots are stronger from the time of emergence than weed roots. Weeding is done by flexible tines, mounted on power-driven circular frames, which revolve in an in-an-out motion through the beet rows. Arrangement of tines and the method by which a row is weeded are similar to that of a revolving egg beater moving sidewise. The unit can be adjusted to weed four rows or when intermeshed to weed two rows at a time. One of the advantages of the intermeshed adjustment is the gentle weeding action around the plants.

The machine can be operated at about 2½ to 3 miles per hour. The size of the beets determines the operating speed and whether the machine should be used as a two-row or four-row unit. Best results have been obtained when the beets were in the two-leaf stage. In use on two rows at a time 23.6 percent of the weeds and 13.7 percent of beet seedlings were removed. Adjusted for four-row operation the machine removed 40.1 percent of the weeds and 16.4 of the beets.

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[2] Hereafter, where the U. S. Department of Agriculture has given assistance in a specific field, that cooperation is indicated by the notation "(coop. USDA)."

Tractor attachment for weeding vegetables

A home-made piece of equipment, developed by the Virginia station, can be hooked to the rear of a tractor to save labor in weeding commercial vegetable crops such as spinach, kale, and collards.

This attachment permits an early shallow, preemergence cultivation of the entire soil surface after the crop is planted, and again at the time the seeds are sprouting and beginning to come through the ground. The weeder is made of an 8-foot length of flexible, heavy-gage woven wire fencing cut wide enough to extend across the bed. Part of the strip (about 1 foot of its total length) is held clear of the ground by the tool holder of the tractor, while the remaining 6 feet rest on the soil surface. The wire fencing is the type woven to form 2-inch squares with diagonally opposite corners, pointing forward and backward. The attachment can be constructed by any farmer with a few hours' labor and at a small cost.

Low volume spraying of vegetables

An inexpensive tractor-mounted sprayer has been developed by the New York State station for the application of insecticides to certain vegetable crops. Construction details and recommendations for its use are available. This sprayer may be constructed by the grower at a cost of less than $150. It is suitable for spraying such canning crops as beans, cabbage, carrots, peas, and possibly broccoli. The sprayer is operated at about 80 pounds pump pressure and requires only 15 to 20 gallons of spray mixture to cover an acre of crop. The advantages of this machine over dust-treating the crops are that it is less expensive, probably less hazardous to the operator, and will give better results under windy conditions. The sprayer does not handle wettable powders satisfactorily, hence most currently used fungicides cannot be applied with it.

Improved ground spraying of cotton

A new-type rig for use in the ground-spraying of cotton with organic insecticides has been developed by the Mississippi station (coop. USDA). This rig not only overcomes a technical difficulty involved in ground-spraying with the newer insecticides, but combines the spraying with cultivating operations.

Very small quantities of the highly concentrated organic phosphate liquids are required when applied by airplane. However, similar quantities applied in more dilute form with ground equipment proved unsatisfactory. In seeking the reason for this, engineers learned that when sprays are applied from airplanes the atmosphere modifies the size of particle and the distribution and thereby permits a more uniform coverage. This disparity between air and ground distribution was overcome by attaching special-type spray nozzles to the new ground spray rig which in turn is attached to the cultivator. This new device makes it possible to spray and cultivate at the same time.

The Mississippi spray rig includes a tank for the insecticide and a pump with the necessary strainers and valves for supplying pressure, together with hose and piping to carry the liquid to the nozzles.

Since cotton must be cultivated repeatedly during the growing season, this new spray rig attachment on the cultivator eliminates special trips over the field for spraying. Mixing the insecticides and filling the spray tank are the only additional operations necessary, but they require only a few minutes. The rig can be attached or detached quickly from the cultivator.

High-clearance mule-drawn cotton sprayer

The Tennessee station developed a cotton sprayer for use on a two-wheeled, high-clearance, mule-drawn cart. Its advantage lies in the fact that it has a higher clearance and thus does less damage to large cotton plants than tractor-mounted sprayers. It can be used in muddy fields to maintain a spray schedule. Being mule-drawn it releases a tractor for other farming operations during the busy crop season. Although specially adapted to cotton spraying, it can also be used to spray other crops. The unit can be assembled in the ordinary farm shop and its low cost makes it practical for small growers. It consists essentially of the cart, a spray kit which includes a low pressure pump, low-volume nozzles, hoses, valves, boom, pressure gage and line strainer, a 30-gallon oil drum, and a 1-horsepower air-cooled engine.

Mechanical stripping of sugar-beet leaves

A self-propelled, tricycle-type machine for removing the leafy portion of sugar beet tops has been developed by the Colorado station. The machine was devised as a result of studies showing that leaves of sugar beets contain the major portion of the carotene and protein of the whole tops. The leaves also contain less moisture than stems and crowns and would be easier to dehydrate than the complete top. Research feeding trials are under way to determine the value of this material for livestock.

The machine has an operating width of four rows. Its dagger-like knives mounted on revolving drums comb through the beet tops and strip off the leaves. The machine operates most efficiently at a speed of about 2½ miles per hour.

A hinged elevator lifts the leaves to a truck or trailer driven alongside the rows that can be quickly folded back over the stripper for convenience to store it or to move it between fields. Normally about 70 percent of the leafy material is recovered, and the remainder of the beet top can be utilized as pasture or silage. The harvesting capacity of the machine in fields of exceptionally heavy tops is about 7½ tons per hour.

Minimizing bruising in potato harvesting

The emphasis in potato harvesting today is on machinery that will dig and sack a greater quantity of potatoes without bruising them. Although some injuries occur in transit to distant markets, much of the damage to potatoes comes through the use of poor handling methods at harvest. After carefully studying the problem of potato injury caused by mechanical harvesting, sorting, and grading, and taking fully into consideration principles previously developed by the Pennsylvania and other experiment stations in studies of the same general problem under different conditions, the Idaho station developed a new separating mechanism that removes the dirt from

potatoes with a minimum of bruising. This new machine consists of a series of rubber-covered rollers, that replace the vibrating chain belt used in older machines. Thus the potatoes are cushioned against bruising and a better job of separating dirt and potatoes is done than with former equipment. Capacity per square foot of separating surface is greater in the new machine than in the conventional types and the operation is improved under damp and muddy field conditions. The new equipment permits the harvesting of potatoes with practically no injury. Idaho farmers are modifying older type diggers by incorporating in them the new rubber-covered rollers. Industry is also incorporating these features in new models of potato combines.

A combination mechanical dirt-remover and bucket-type vertical elevator developed by the Maine Experiment Station is also overcoming some of the potato-bruising difficulties experienced by potato growers. The dirt-removing machine is powered by a ¾-horsepower electric motor and can clean 135 barrels per hour. During an extensive test it separated about 1 barrel of field dust for each 100 barrels of potatoes, with no evidence of tuber bruising. The Maine station has also made available plans for a portable-type, variable length conveyor for use around the potato storage house. This conveyor has proved highly satisfactory in tests and has met the rigid requirements of the potato-growing industry. It can be built in any farm machine shop.

Mechanical onion harvesting lowers costs

The largest expense item in commercial onion growing has been that of stoop labor at harvesting time. Costs for harvest labor should be materially reduced as the result of a special mechanical harvester developed by the California station. The new machine digs, lifts, tops, and sacks the onions, whether seeded or transplanted, and under all types or conditions of soil in which onions are usually grown. This compact unit can be readily adapted to a wide range of tractor mounting and operating conditions.

When the unit is in operation, synchronized, two-bladed rubber flippers lift the downed tops so as to engage them between two parallel endless belts running at an incline of 30°. Simultaneously, a special, single, narrow, wedge-shaped digging blade passes under the onion bulb, breaks the surrounding soil, and severs the onion roots. The inclined belts and the forward movement of the tractor lift the onion from the soil. The onion continues to travel upward to a point where another series of parallel endless belts grasp the tops slightly above the first set. The tops are thus held firmly at two points. As the onions pass between two overlapping disks, the bulbs are severed from the top. The severed tops are conveyed over the back of the machine and fall to the ground, and the onion bulbs drop into a hopper from which a standard elevator conveys them to a sacking platform.

At a tractor speed of 1 mile per hour in an average stand of onions, the machine can lift about 240 onions per minute. With ordinary delays such as are encountered in turning at the end of the row, 2 men on the machine can harvest about 2 acres in a 10-hour day.

Adaptation of the California onion harvester is already under way at the Oregon station which is developing a similar machine for digging and packaging gladiolus bulbs.

Castor-bean harvesting mechanized

A tractor-mounted, two-row castor-bean harvester to be used on the taller and more rugged plants grown on the Southern Great Plains has been developed through cooperative efforts of the agricultural engineers and agronomists of the Oklahoma station (coop. USDA).

The new machine contains a rotary beater mechanism that strips the castor-bean capsules or pods from the plant without pulling the plants from the ground. A gathering unit feeds the plants into the harvester where fabric beaters strip the pods from the plant. The capsules are moved by augers onto an elevator, which carries them to a trailer wagon. Improved varieties, planting practices, and machinery resulting from research in the mechanization of castor-bean harvesting will aid growers in producing this strategic oil crop on 200,000 acres. The proposed acreage for 1952 which is two and one-half times that of 1951 and nearly thirtyfold more than planted in 1950 is expected to supplement imports and to augment military demands for castor-bean oil. The oil is also used in the manufacture of nylon, paints, and many other peacetime products.

The finger-wheel hayrake

A new principle of mechanical operation has been incorporated by the North Carolina station in developing a side-delivery hay rake. The machine consists of individually floating wheels set in echelon and at an angle to the direction of travel. Around the periphery of each wheel is a series of backward-curving teeth or fingers. Pulling the diagonally set wheels with these fingers attached produces a dragstroke action which moves any loose material on the ground approximately parallel to the angle on which the wheels rotate. These backward-curving fingers or rods facilitate the shedding of the material being raked without changing the dragstroke action.

Three basic frame mounting arrangements have been used by the engineers to test the new raking principle. All three have been used at either the front or rear of the tractor. When the rake is in operation, the independently floating wheels automatically adjust themselves to uneven terrain and make the machine more efficient in raking all of the hay. The windrow formed by the new rake is more uniform in size than that formed by conventional machines. Indications are that a lighter rake may be built through the use of this raking principle because no weight is needed to insure that the supporting wheels resist all developed side thrusts. The calculated side thrust component of the full force amounts to approximately 350 pounds and is absorbed by the tractor.

Experiments with the new rake have given such promising results that it is expected to find an important place in filling the need for more economic forage handling on the farm.

Silage conveyor and powered feed bunk saves time and labor

A recent development for conveying and distributing silage to feed bunks is reported by the Oregon station. A 10-foot chain-type silage conveyor, used alone or in combination with an electric-powered cleat-chain feed bunk, performed satisfactorily. The cleat-chain feed bunk distributor cleans out all residual material exceptionally well

and places fresh silage in bunks 60 feet long. Animals may feed from either side of the bunk. The silage conveyor works well in silos 14 feet or larger in diameter and effects a 40-percent saving in time required for feeding down the silage. The powered cleat-chain bunk saves from one-third to one-half of the time formerly required in silage conveyance and distribution because it eliminates second handling.

Picking lemons mechanically

Mechanical picking of lemons with a new-type lemon clipper developed by the California station has increased the actual fruit-picking rate in California by 30 percent and increased the over-all rate in harvesting productivity 10 percent during 1951 field trials. The clipper blades are placed on the lemon button and closed. The blades ride on the button and cut the stem off at its juncture with the fruit. This operation greatly reduces the number of lemons rejected on the market as "cut-buttons."

With this new clipper the picker merely finds the fruit and cuts it from the stem at the button. This avoids the older practice of cutting the stem twice, which consumes approximately 24 percent of the time required to select and cut the lemon from the tree.

Because of a special finish on the cutting edges of the new clipper its wear rate is considerably longer than that of the old-model clippers that do not hold an edge for very long periods. Thus frequent sharpening in the field is not necessary. In fact, the new cutter cannot be sharpened in the field, but the expected use-life of its cutting edges is so long that keeping the cutter sharp does not present a serious maintenance problem.

Sorting lemons electronically by color

In connection with a joint study of problems unsolved in the marketing of fruits, an electronic machine for sorting lemons according to color under packing house conditions has been developed by the agricultural engineers and economists at the California station (coop. USDA). A similar machine for electronically sizing lemons was reported in 1949.

Perfection of the color sorter followed discovery that in a particular portion of the infrared region of the spectrum, yellow lemons had 90-percent reflectivity, whereas dark green ones had only 10 percent. The new machine measures the amount of light reflected by the lemon. A metering device feeds the lemons in single file into a sorting chamber. When the lemon passes through a bank of light-sensitive cells, its reflectivity response sets up a series of electrical operations. Impulses in the power circuits of the system control gates that route the fruit into its correct color class. The single-unit machine now available sorts four to five lemons a second, and a new unit of higher capacity is now being constructed.

Since the amount of chorophyl present affects the amount of light reflected to the light-sensitive cells, this color sorter may prove useful in grading other farm products that are marketed largely on a state-of-maturity basis. Laboratory tests indicate that red apples, oranges, and tomatoes could be commercially sorted with the color-sorting machine by making minor changes in it.

Screening chicory seed from birdsfoot trefoil

Competition from chicory or "blue wood," a weed that ripens seed at the same time as birdsfoot trefoil, is a serious obstacle to greater use of birdsfoot trefoil as a hay and forage crop in the Northeastern States. Chicory cannot be separated satisfactorily from trefoil seeds by the customary screening and air-cleaning methods because the seeds of both plants are of approximately the same size and weight. The Vermont station studied the characteristics of each kind of seed and found that trefoil seed is much rounder than chicory seed. The station then developed a simple machine that separates the "rollers" or round trefoil seeds from the "riders" or flatter chicory seeds. An inclined revolving belt or platform allows the round seed to roll off, whereas the flatter seed rides to one side. With this new machine at their disposal, farmers may now plant birdsfoot trefoil seed that is free from this weed seed.

Automatic removal of strawberry caps

The Tennessee station has perfected a machine that automatically removes the stems and caps from freshly picked strawberries. In tests 6,625 pounds of strawberries of five different varieties this machine removed more than 96 percent of the caps with less injury to the fruit than when hand capping was used. Farmers selling strawberries to commercial canneries previously were responsible for capping as well as picking the berries. A picker can gather about half again as much fruit when not required to pick and cap the crop.

The new machine can do the work of approximately 130 hand cappers. It consists essentially of a rotating vertical drum or barrel and a series of pairs of rubber-covered and fluted metal rolls. Uncapped berries are fed into runways and are directed inwardly and against the rotating rolls and drum. The brushing action of the drum on the berries propels them along the length of each runway and the stems and caps are grasped and pulled free by cooperating pairs of rolls. Capped berries are discharged at one common point at the end of each runway onto inspection conveyors. Suitable water sprays placed about the machine serve to wash away loose caps and other debris.

In the past, capping has been one of the most expensive operations in preparing strawberries for commercial canning and strawberry preserve making. The new machine is expected to lower processing costs in an industry that packed 193 million pounds of strawberries in 1950.

Temperature and humidity control for tobacco curing

Agricultural engineers of the North Carolina station have developed a new thermostat that controls the temperature of oil-burning heaters used in flue-curing tobacco barns within a range of 1° to 2° F. In addition the thermostat automatically allows the temperature to rise at any desired rate as curing progresses. Incorporated in the instrument is a device for regulating the humidity in the barn by increasing or decreasing the amount of ventilation. Accurate regulation of the temperature and humidity should result in a saving of fuel in curing and in a much higher quality of cured tobacco.

A simplified antismut treatment

The West Virginia station has developed another short cut in the treatment of wheat and barley seed to protect it against loose smut. The new device combines the principle of the hot-water seed treater and the warm-air seed drier, and is a modification of the hot-water bath developed by the Oklahoma station in 1940. It utilizes steam heat and permits accurate control of the temperature of the bath and of the time of soaking. The drier treats 2-bushel lots of the bathed wet grain with air heated from 110° to 120° F. An automobile radiator attached to a steam or hot-water line is used for heating. Air is forced over this radiator by a centrifugal blower having a capacity of approximately 1,200 cubic feet per minute. A ¾-horsepower motor is used as power for the fan.

Economical drying of baled hay

Baling hay before it is entirely field cured has become a modern, and frequently desirable, practice on mechanized farms, particularly where inclement weather is imminent. However, driers for baled hay have been costly. The North Carolina station has developed a baled-hay drier that is fast and economical to operate and does not call for a heavy original investment. The drier reduces the moisture content of bales from 35 to 19 percent in 16 to 22 hours at a cost of $2.85 per ton, when fuel oil costs 11.9 cents a gallon. The drier permits the use of high but carefully controlled temperature.

Mechanical drying of corn and small grains

The Illinois station (coop. USDA) developed an inclined-column, batch-type, shelled-corn and small-grain drier. Grain is dried and cooled simultaneously in two chambers with one fan and one heater. This permits continuous operation of the heater and fan for increased drying capacity. Greater efficiency is obtained through heat regained from the dried grain. Shelled corn with 26 percent moisture was dried to 14 percent in a farm-built drier of this design at a cost of 2.5 cents a bushel for fuel and power. Efficiencies and drying rates compared favorably with those of other drying systems.

Practical reduction of moisture in newly harvested ear corn to safe levels for storage in prefabricated steel buildings was accomplished by using forced air at prevailing outside temperatures. The cost for electricity to drive the fan was about 0.5 cents for each bushel of corn dried. Corn left in the field did not lose moisture so fast as the ventilated corn, and hence was subject to additional field losses from bad weather.

Forced ventilation cuts tobacco curing costs

A forced-ventilation system using a fan to circulate the air through tobacco-curing barns has been developed by the Virginia station to meet the need for lowering bright tobacco curing costs.

The new system may lower the over-all cost for fuel and labor per unit cure. From 40 to 50 percent more tobacco may be cured in a standard barn at a lower cost than by the usual methods. The extra capacity is obtained by packing the sticks closer on the tiers. There

is no damage from either sponging or scalding. It is possible to cure at lower temperatures during the final stages without prolonging the curing time. These lower temperatures lessen the fire hazard.

Records show that the average cost of coal and electricity for nine curings with the forced-ventilation system was 82 cents per 100 pounds of leaf cured. The average fuel cost for the same barn for 14 curings, previous to installing forced ventilation, was $1.08 per 100 pounds of leaf cured. The costs for an oil cure in a similar size barn for nine curings during the same period was $1.92 per 100 pounds of leaf.

The color and quality of leaf cured by the forced-ventilation system and subjected to a forced aging process were equally as good as those of tobaccos cured with other systems. Chemical analyses of samples and smoking tests showed no significant differences between the quality of the forced-cured and aged tobacco and that cured by conventional methods.

Speeding fruit and vegetable treatment for canning

The Tennessee station has developed a practical, easily built machine for automatically immersing freshly cut fruit or vegetables in antioxidizing solutions used in the commercial canning industry to prevent discoloration during canning.

The sliced fruits or vegetables to be treated are channeled into one end of a simple mechanized semicircular tank containing the treating solution. At the center of the semicircular tank are four equally spaced arms extending outward. Pivotally mounted at the outer end of each arm are perforated metal baskets. The baskets receive and submerge the fruits to be treated, slowly propelling them to the opposite or discharge end of the tank. The special arm and basket arrangement, together with a suitably mounted tripping mechanism, allow the treated material to be drained properly, after which it is routed to an inspection belt or into a suitable container. All action is continuous and completely automatic. In tests it was shown that 1,000 pounds of product per hour could be treated easily.

FIELD CROP RESEARCH

Contributions made in field crop research during the past year include the development of improved crop varieties and effective tillage, fertility, cultural, and harvest practices. Chemical weed control practices developed in connection with the growing of different crops have resulted in a reduction in hand labor, and in the number of repetitive cultural operations, and in profitable mechanical culture and harvest methods.

Corn

Corn hybrids developed by the experiment stations, the Department of Agriculture, and commercial seed companies have increased yields about 30 percent or 750 million bushels a year. The 350 hybrids released by these several agencies in the past 25 years have been bred for uniform height of ear, strong stalks, and uniform maturity, factors that facilitate mechanical harvesting; for resistance to diseases and insects; for use as ensilage; and for adaptation to different sections of the country. These hybrids have been widely

accepted in the Corn Belt and their use continues to expand rapidly in other areas.

AES 805, a new corn hybrid developed by the Illinois station and adapted in northern Illinois, has averaged 99 bushels per acre yield compared with 90 bushels for seven other hybrids. It also excelled in resistance to lodging, smut, and leaf blight, dropped no ears during harvest, and the ears were usually free of husks, a desirable attribute in connection with machine harvesting. AES 702, also developed by the Illinois station and adapted farther south in the State averaged 83 bushels an acre yield, surpassed eight others in resistance to leaf blight and lodging, and equaled them in all other characters.

Minhybrid 411 and Minhybrid 412, developed by the Minnesota station, are resistant to the larvae of the first brood of European corn borer, and a third AES 610, is borer-tolerant and shows a low percentage of stalk breakage from borer damage. Minhybrids 508 and 409, new productive hybrids excelling in standing ability, resemble older recommended hybrids in their reaction to borer.

Michigan 250, a Michigan station hybrid with 85-day maturity, adapted to corn areas in northern and extreme east central Michigan, is a good grain producer. Michigan 350, which ripens in about 90 days, is adapted to northern and north central Michigan and has also made exceptional grain yields on muck soils in south central and southern Michigan. K1830, a yellow hybrid developed by the Kansas station (coop. USDA), and found superior to K1585, is recommended for southeast and south central Kansas.

Okla. 301, bred by the Oklahoma station for Oklahoma conditions, outyields the average of currently recommended hybrids by 10 percent, has a tight husk which protects it against ear worms, and stands well. Texas 15–W, a white hybrid developed by the Texas station, outyields other white hybrids now sold and stands well. It is adapted to the Blackland Prairie, where it may replace Texas 11–W. Dixie 82, a high-yielding hybrid with good roots and stalks, developed by the Department and the North Carolina station in the southern cooperative corn improvement program, matures a week earlier than Dixie 18 and ripens slightly later than hybrid N. C. 27, both of which it has outyielded.

VPI 802 and VPI 645, hybrids developed by the Virginia station, are resistant to stalk rot and leaf blights and to lodging. VPI 802 outyields and matures a little earlier than U. S. 262 and U. S. 357, and VPI 645 is a little later than U. S. 13. VPI 802 is recommended for eastern Virginia, and VPI 645 for sections west of the Blue Ridge and for northern Piedmont.

Connecticut 103, an inbred containing as much sugar in its stalk juice as sugarcane, is one of the best ensilage inbreds developed by the Connecticut Agricultural Experiment station. It has strong stalks and resistance to aphids, leaf blight, and stalk rot, and has been used extensively in the Midwest in double-cross hybrids. Connecticut 845, a hybrid that contains four sugar inbreds of this station and is now in commercial production, stands well, resists stalk rots and leaf diseases, and produces good yields of grain and silage.

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Growing hybrid corn without detasseling

Research at this Connecticut station and at Illinois and other stations has resulted in the development of a promising method for growing hybrid seed corn without the tedious and costly hand removal of tassels. The method is based on using in crossing fields, corn plants that produce no pollen on their tassels (male-sterile) but that have normal seed-making parts as the female parents. Almost any standard hybrid or inbred corn can be made pollen-sterile by an ingenious method of crossing and backcrossing. The process is now being adopted in commercial hybrid seed production. The Illinois station estimates that complete elimination of detasseling in commercial hybrids seed production will effect an annual reduction of about $10,000,000 in cost of production.

Varietal influence on oil and protein content

The possibility of developing high-yielding corn which is also high in oil and protein for feed and industrial use has been considered by the Illinois station (coop. USDA). Analyses by the station of about 300 varieties submitted by private producers during a period of 3 years and also of some of its own hybrids, revealed that actual contents of oil and protein in the corn vary markedly with season and soil fertility. However, varieties that are high in protein or oil for any one year are also high in other years. High yields do not affect the contents of protein or oil. The protein content of the varieties ranged from 8.6 to 11.7 percent (3-year average) and oil content from 4.3 to 4.8 percent.

Response of corn to measured fertilizer rates

The advantage of growing adapted corn hybrids in suitable stands and with proper fertilizer rates was shown by the Mississippi station (coop. USDA). Corn to which no nitrogen was applied and which was thinned to the former rate of 4,000 plants averaged 22 bushels per acre yield compared with 72 bushels when 120 pounds of nitrogen per acre was applied and the stand was increased to 12,000 plants per acre. The fertilized plants also produced grain with 1.74 percent more protein. Weeds were better controlled, crop residues were increased, and a greater amount of soil organic matter was built up in the fertilized crops than in the unfertilized crops.

Weed control in corn fields

A program for controlling weeds in corn, reported by the Iowa station (coop. USDA), calls for a combination of tillage practices, herbicides, clean seed, and crop rotations. No single method has sufficed. Among primary tillage methods, plowing was placed first, with listing a close second; these methods have consistently given higher yields and usually have resulted in better initial weed control than disking or subsurface tillage. Between primary tillage and planting, once-over with a tandem disk harrow, followed by a spike-tooth harrow just before planting, gives best weed control under ordinary conditions. With adverse conditions, additional tillage with the disk-harrow or duckfoot cultivator may be advisable. Early cultivations with a weeder, rotary hoes, or spike-tooth harrow usually control small

weeds as well as the sweep cultivator. Sweeps and disk-hillers give best weed control when used for late cultivations, and such cultivations may be aided by a postemergence application of herbicide.

Preemergence application has been most effective as 1 to 2 pounds per acre of 2,4-D acid equivalent (preferably ester forms) in 5 to 10 gallons of water, at or soon after planting. Although preemergence treatment may result in excellent weed control with two instead of the usual three cultivations, under some conditions it may damage crops and fail to control weeds. Best results with postemergence spraying, mostly to control susceptible broadleaf weeds, have been obtained with 0.5 pound of acid equivalent of the sodium or amine salt of 2,4-D or 0.25 pound of the ester in 10 to 15 gallons of water. Proper equipment for the task is essential and certain precautions are to be observed. It is important, also to use weed-free seed, clean harvest equipment, and weed-free hay and bedding material.

Wheat

Additional varieties of wheat developed by the experiment stations and the Department, and expected to help maintain the current high level of national production, possess such characters as stiff straw and resistance to shattering and bleaching when left in the field, which facilitate harvesting them mechanically. They make high yields, mature early, are winter hardy and resistant to diseases and insects, and have desirable milling and baking qualities.

New wheat varieties

Ponca, a new hard red winter wheat variety developed by the Oklahoma and Kansas stations (coop. USDA), resembles Pawnee but is much superior to Pawnee in resistance to hessian fly and leaf rust. The grain of Ponca does not bleach as readily or sprout in the head or shatter as much as Pawnee does if left standing in the field, and it also is superior in milling and baking properties. Ponca is recommended for Oklahoma southeast of the Panhandle and several nearby counties. Apache, a new hard red winter wheat developed by the Kansas, New Mexico, and Oklahoma stations (coop. USDA), is recommended for northeastern New Mexico and adjoining parts of Colorado and Oklahoma. Intermediate between Early Blackhull and Comanche in maturity, Apache has good test weight and good milling and baking qualities, but is not resistant to rusts or smuts.

Sioux, a new hard red winter wheat developed by the Nebraska station (coop. USDA), has excellent bunt resistance, is winter hardy, and has strong straw, and good milling and baking qualities. Sioux is recommended for central and western Nebraska, where it equals Cheyenne and Nebred in yields. Anderson, a high-yielding intermediate variety, resistant to leaf rust, moderately resistant to mildew, was developed by the South Carolina and North Carolina stations (coop. USDA) from a Leapland-Fronteira cross.

New strains of wheat resistant to the destructive wheat jointworm, bred in research by the Missouri and Kansas stations (coop. UDSA), are providing resistant parent stock for use in developing good quality, high-yielding varieties. Twenty-four strains derived from a cross between wheat and wheatgrass proved resistant to wheat jointworm.

Seven of these were also resistant to hessian fly and several showed resistance to stem and leaf rusts. Current cultural methods of control are often ineffective, and unless practiced on a wide scale are of little value, because adult wheat jointworms (small flies) may drift in from other uncontrolled fields.

Time element important in seedbed preparation

According to 11 years' research at the Nebraska station, there is a big difference in yields between winter wheat planted under different methods and at different times. Fields plowed 7-inches deep on July 15, and disked on August 15 and again just prior to seeding, gave an average yield of 33.9 bushels per acre. When August disking was omitted, the yield was 6.7 bushels lower. Wheatland plowed 7 inches deep on August 15 after being disked July 15 and again just prior to seeding, gave an average yield of 31 bushels. Omitting the July disking lowered the yield about 1.5 bushels. With no supplementary tillage to control weeds, plowing on August 15 gave better results than either earlier or later plowing. Later plowing with various diskings resulted in still lower yields. Plowing depth has far less effect than plowing date on the yield. A slight yield increase might be expected as soil is plowed deeper (7 inches) during July and August. With late September plowing a 4-inch depth was enough for maximum profit. No benefit resulted from plowing to a depth of 10 inches.

Barley

Kenbar, a new winter barley developed by the Kentucky station (coop. USDA), has outyielded commercial varieties by 4 to 18 bushels per acre. Kenbar is resistant to five of the seven known races of "nuda" loose smut, which often causes up to 20-percent reduction in yield of commonly grown varieties, and also to barley scald and mildew. Winter-hardiness, short, strong straw, and early maturity are among its other advantages. It has produced 3,042 pounds of grain per acre at the Mississippi station, equivalent by weight to 95 bushels of oats, and has resisted lodging. Hudson, a winter variety developed by the New York (Cornell) station, has outyielded Wong, widely grown in New York, by an average of 13.9 bushels per acre, or 34 percent in 5 years and has also been more winter hardy.

Goliad, a new disease-resistant barley, was developed for winter forage under south Texas growing conditions by the Texas station (coop. USDA). It also produces good grain yields when the top growth is not injured severely by late winter freezes. It is resistant to the common races of leaf rust, stem rust, and powdery mildew and to spot blotch and net blotch. Goliad has tall, strong straw, and an erect, spring-type growth habit and, when planted early in the fall, makes more fall and early-winter growth than winter-type varieties.

Kearney barley, selected by the Nebraska station (coop. USDA), is recommended for an early-maturing grain crop and for fall and winter pasture. It is more winter hardy than Reno and Ward, both older varieties. Dicktoo, a high-yielding, winter barley developed by the North Dakota station (coop. USDA), matures early and like Kearney is much more winter hardy than Reno.

Oats

Arkwin oats, a winter variety developed by the Arkansas station, has shown exceptional winter hardiness and provides good winter pasture. Also characterized by large foliage, upright growth habit, and medium tall plants facilitating combining, it has outyielded the more common Traveler, DeSoto, Ferguson, Fulgrain, and Red Rustproof varieties. Arkwin is resistant to common races of smut, Helminthosporium blight, red spot mosaic, older races of crown rust, and is moderately resistant to race 45.

Sorghum

Darset, a dwarf, combine-type darso developed by the Oklahoma station (coop. USDA), will extend grain sorghum production eastward into areas where bird damage and weathering reduce yields of existing noncombine types requiring hand harvesting. Darset, essentially Okla. No. 1 darso with addition of the dwarf plant character, is suitable for combine harvesting, and is a week to 10 days earlier. Both varieties are resistant to Periconia stalk rot (pythium rot or milo disease) and remain standing under conditions in which regular darso lodges. Dwarf Kafir 44–14 and Redlan, previously released, are providing improved yield and greater disease and insect resistance for central and western Oklahoma. Both outyielded leading combine milo varieties in trials at Woodward in 1951.

Cotton

Different cotton varieties were grown by the Mississippi station (coop. USDA) under the best known mechanical practices of production, harvesting, and processing to determine picking efficiency (ratio of seed cotton harvested by machine to cotton open and pickable) and cleanability (reaction to cleaning and ginning after machine picking). Differences in picking efficiency of different varieties of cotton between tests and between the years can be caused by the degree of efficiency obtained in operating mechanical equipment, the degree of maturity of the cotton, the degree of defoliation, and other factors. No variety consistently surpasses all other varieties in picking efficiency. Lowest efficiency is shown in Miller, a short, coarse variety. In this variety there is an excessive falling out of locks even under normal conditions. Picker efficiency usually rises in varieties that give higher yields of seed cotton and drops in varieties with reduced yields. The composite grades or cleanability of the several varieties vary between tests and from year to year. Miller has been slightly higher in grade in tests where planted. Wilds, a 1¼-inch-staple variety, has equaled most other varieties in picking efficiency and grade.

Cotton yields have been increased 59 percent over 25 years by the Texas station (coop. USDA) and runoff and erosion minimized by contouring and terracing relatively level cotton land. Tests have also shown that cotton yields can be predicted with reasonable accuracy if the depth of soil moisture is known at planting time. With soil moisture less than 1 foot deep, lint yields have averaged 44 pounds per acre; 2 feet deep 110 pounds; 3 feet deep 170 pounds; and 4 feet

deep 300 pounds. Such information enables farmers to develop flexible cropping systems and to select crops that will make best use of water and soil under prevailing moisture conditions.

Wide-scale application of experimental results obtained by the Texas station, in using chemicals to control grasses and weeds in cotton may result in a saving of 10 to 15 million dollars in annual hand labor costs in producing cotton in Texas. Tests showed that hand hoeing and regular cultivation of the row was more expensive than any system that included the use of chemicals. Six hoeings were needed to keep the rows clean and cost $13.30 per acre in hand labor where no chemical was used. Application of dinitro preemergence chemical at planting and two postemergence oilings 7 days apart after the cotton was 3½ inches tall, reduced hand hoeing costs to $3.29 per acre. Chemical treatments controlled 97 percent of the Johnson and annual grass seedlings; hand hoeing in this system was practically limited to scattered spots of established Johnson grass in the row. Regular sweep cultivation was used in all systems to keep the middles clean. The Mississippi station (coop. USDA), Louisiana, Alabama, and other stations have also recommended definite precautions to be followed in using chemicals for weed control in cotton, to minimize hand hoeing and cultivation.

Flax

Marine, a new seed flax selected by the North Dakota station (coop. USDA), is immune from North American races of flax rust and has satisfactory wilt resistance. It has yielded well at most stations where tested in the North Central region.

Punjab 53, a new seed flax developed by the California station, produces 48.6 bushels per acre, and has outyielded other wilt-resistant varieties. Its oil content tests at 40.5 percent, 1 percent higher than the older high-yielding Punjab varieties.

Contrary to opinion in the main flax-growing area of the Northwest, the North Dakota station finds that flax is not a heavy mineral feeder and does not deplete soil excessively. The average flax crop removes smaller quantities of nitrogen, phosphorus, potassium, and sulfur than do crops of wheat, oats, or barley. Although flax does remove more calcium than the other crops, calcium is not a limiting factor of crop production in the Northwest.

Peanuts

Field germination of seed is an important factor in obtaining profitable stands of peanuts. The Alabama station obtained best germination from seed grown in fertile and well-watered soil, cured to 6-percent kernel moisture under conditions that limit damage to 2 percent or less, and stored in the shell at below 35° C. and a relative humidity that did not permit kernel moisture to exceed 6 percent.

Danger from loss in field drying of peanuts has been reduced by the North Carolina station (coop. USDA) by windrowing with a digger-shaker, loading after 2 to 12 days with a standard-type hay loader, and artificially drying with forced warm air before picking. Peanuts harvested in this manner showed a maximum damage of 19 percent of

the crop as compared with 45 percent when they were picked as soon as harvested and artificially dried. Windrowed peanuts have a better external appearance and better flavor than those dried immediately after digging, and the cost of windrowing is no greater than that of curing by the older stack pole method. Windrowing clears the field sooner, permitting cover crops to be planted.

An increasingly larger part of the Georgia peanut crop also is being cured in windrows. The Georgia station finds that exposure of pods to direct sunlight for longer than 2 days can lower germination and affect edible qualities of the peanuts. Pods partially protected from direct sunlight during curing suffered no loss in viability. Certain chemical changes apparently occur in the curing peanut which require moderate temperature and some time for effective accomplishment.

Dixie Spanish, a new peanut variety selected by the Georgia station from Spanish 146 (originally from India), has outyielded other Spanish selections by substantial margins.

Soybeans

Perry and Dorman soybeans are ninth and tenth, respectively, in a series of superior varieties released in a decade as the result of breeding work at stations of the soybean-growing States and the Department. Other varieties in the series recently released that are adapted in belts from North to South are Monroe, Blackhawk, Hawkeye, Adams, Lincoln, Wabash, Ogden, and Roanoke. Perry, a productive, full-season erect, yellow-seeded variety, high in oil content, and about 5 days later than Wabash, is adapted to a 100-mile belt north and south extending across southern Indiana, Illinois, Missouri, and Kansas. Dorman was developed especially for the upper Mississippi Delta and the mid-South. Its adapted area is between the belts producing the Perry and Ogden varieties. Seed yields of Dorman have usually surpassed those of S–100 which it will replace, and often have equaled those of Ogden, that matures 14 to 18 days later. Its oil content is 2.5 to 3 percent higher than S–100. Dorman, similar to Ogden, provides good ground cover, which aids in suppressing annual weeds and grasses.

The Improved Pelican soybean, developed by the Louisiana station (coop. USDA), is viny and makes cover enough to hold other vegetation in check throughout the summer. The yellow seed have high oil and protein contents, and its yields approximate 30 bushels per acre. The new variety is adapted to the sugarcane area and other sections in which heavy growth for hay or soil improvement is needed.

Potatoes

Knick, a new potato variety developed by the Alaska station, yields 50 to 60 bushels more of U. S. No. 1 tubers per acre than Arctic Seedling, the standard for the Territory. The 15-percent increase in total tonnage per acre actually amounts to about 25-percent increase in terms of edible tonnage, for Knick has very shallow eyes which reduce the loss in culinary preparation. It does not develop hollow heart or sprout in storage.

Idaho station experiments show that light and frequent irrigations give best yields of good quality Russet Burbank potatoes. The sprinkler system used about half as much water as the furrow system to maintain equal soil moisture contents. Time of irrigation evidently should be determined by soil moisture content (there should not be more than 70-percent depletion in the top 10 inches) rather than by calendar. The first irrigation should come before plants are 30 days old. A little overirrigation at this time has shown no harmful effects, whereas insufficient irrigation early in the season has resulted in lower yields and quality. Frequent light irrigations in the hottest part of the season (as in July) have kept the soil cooler and have reduced the amount of pointed-end, bottleneck, and undersized tubers, and other undesirable features.

Killing potato vines prior to harvest facilitates digging and picking operations. The Colorado station has found that the practice of beating off the vines is superior to the other mechanical vine-killing methods—burning and undercutting. Sodium arsenite is preferred to other chemical sprays. Vine killing generally reduces the yield and specific gravity of the tubers. Tuber color is a more intense red on early-harvested than on late-harvested potatoes. Skinning is reduced by vine killing and is reduced further by allowing the tubers to remain in the soil for a week after the vines are killed. Irrigating 4 days before vine killing increased the yield, decreased the amount of stem-end discoloration, and lowered the specific gravity of tubers. Less discoloration after vine killing occurred with high soil moisture than under drought conditions. This is also supported by North Dakota station findings in the Red River Valley.

Chemical control of weeds in potatoes is one of the major labor-saving procedures employed since the adoption of mechanized potato growing. New York (Cornell) station experiments show that weeds in potatoes can be controlled with one preemergence application of chemicals. About 2 weeks after planting and before the potatoes emerge the chemical, as a dinitro compound, in recommended dilution, is sprayed uniformly on the potato acreage. A later cultivation at hilling to prevent greening of any of the exposed tubers may be desirable. With less labor, these procedures have resulted in clean fields of potatoes and yields equal to those under normal cultivation.

Sweetpotatoes

Onolena, a new sweetpotato developed by the Hawaii station, supplies the market demand for high-dextrin sweetpotatoes not grown previously in the Territory. It has equaled or outyielded the best standard varieties and has kept in best condition for the longest storage period. It has graded better than Porto Rico in baking tests. The tolerant Allgold developed by the Oklahoma station and the resistant Goldrush from the Louisiana station were the only new varieties studied in Mississippi station experiments that were appreciably resistant to wilt and deemed worthy as new table-type market varieties.

Yellow- or orange-fleshed varieties of sweetpotatoes, which are excellent sources of carotene, provide animals and man with an easily available source of essential vitamin A. The Puerto Rico (University) station found that sweetpotatoes (U. P. R. No. 3–Porto Rico)

have higher carotene contents when yields per acre have been increased by the addition of nitrogen and phosphorus fertilizers. The addition of potassium resulted in yield increases but did not affect carotene content. Increases in carotene content have accompanied increases in pH where calcium carbonate was applied to acid soils (pH 4.5). The liming effect of the calcium carbonate, also, increased yields. Boron has increased yields but not carotene content. Neither increased yield nor increased carotene content have resulted from the use of copper, magnesium, or manganese.

Sugar Beets

The Colorado station (coop. USDA), reports that storage rot can be reduced by breeding resistance into present varieties. Beets grown from seed of 16 of 19 mother beets that showed resistance to storage rot were more resistant than were beets of the unselected parent US 226, 6 were lower in rot losses, and none of the progeny of the 19 strains sustained higher rot losses than beets from the unselected parent.

About 46,000 acres of sugar beets in Colorado were thinned mechanically in 1951, as a result of methods worked out by the Colorado station. Mechanically thinned beets have given a higher tonnage yield per acre, have produced a higher gross sugar content per acre, and have been higher in percentage of sugar than hand-blocked and thinned beets included in the experiments. The hand labor on mechanically thinned areas has ranged from 27 to 64 percent of that needed for complete hand work.

Chemical weed control has facilitated the mechanical production of sugar beets. Michigan station experiments (coop. USDA) showed that the application of common salt reduces labor costs in thinning beets. The findings suggest that with the aid of salt sprays mechanical blocking and thinning may replace thinning and early weeding by hand. Trichloroacetic acid (TCA) applied to sugar beets by the North Dakota and Michigan stations (coop. USDA), at the rate of 5 to 10 pounds per acre just before the beets emerge, was particularly effective in killing green and yellow foxtail, *Setaria* spp., the predominant weedy grass of northern sugar beet areas. When this treatment is used under normal rainfall conditions, foxtail may largely be eliminated without any decrease in yield of sugar beets. Ryegrass and chickweed have been controlled in sugar-beet-seed fields through the use of isopropyl-N-phenyl carbamate (I. P. C.) sprays by the Oregon station (coop. USDA). This practice has been accepted by seed growers in Oregon.

Tobacco

Oxford 1–181, a new black-shank-resistant flue-cured tobacco variety developed by the South Carolina station and the Department equals or surpasses, under South Carolina conditions, any available black-shank-resistant variety. Yields, quality, and returns per acre of Oxford 1–181 have been comparable to the better flue-cured varieties on non-black-shank-infested soils. Oxford 1–181, a selection from the same cross as Oxford 1, has characteristics resembling Virginia Bright Leaf, Jamaica, Bonanza, and Yellow Mammoth, and should not be fertilized too heavily with nitrogen, as this treatment may produce a thick leafy-type tobacco not in demand.

More than 75 percent of the shade tobacco grown in the Connecticut Valley in 1952 has been planted to two new strains, Connecticut 15 and 49, developed in the Connecticut Agricultural Experiment Station's improvement program. Connecticut 15 accounts for half of all the shade tobacco acreage grown in Connecticut and Massachusetts. It outyields the strains it has replaced, its leaf color is lighter and more uniform, it produces more high-grade leaves per plant, and its leaf shape is superior. It is also resistant to black root rot and flea beetles, which previously caused shade growers much concern. Connecticut 49, developed later and grown on 25 percent of the 1952 shade tobacco acreage has most of the excellent qualities of Connecticut 15, produces a more elastic leaf—important in cigar manufacture—and its taste is rated as better by some experts.

FORAGE CROPS, PASTURES, AND RANGES

Recent advances in mechanization have made grassland agriculture more practical and economical. New and redesigned machines make it possible to seed and manage pastures and hay crops with less labor and a smaller expenditure of time. Better harvesting equipment has resulted in higher quality forage and reduced costs, and the increase in production of grass and legume seed has created a demand for more efficient seed harvesting and processing equipment. Such machinery is being developed by the close cooperation of the State experiment stations, the Department, and machinery manufacturers.

Increased attention is being given to the production and utilization of forages and pasture crops and a great amount of research is being devoted to rangeland improvement. One of the high lights of the past year was the Sixth International Grassland Congress held at The Pennsylvania State College. This was the first time the Congress had been held in the United States and it afforded an excellent opportunity for research workers and others interested in grassland agriculture to exchange information and to study new methods and techniques used in many parts of the world. Grassland agriculture is comparatively new in the United States and the findings of research in other parts of the world are of great value to our own research workers.

Much attention is being given to the many phases of forage crops research at all of the State experiment stations and the following paragraphs present only a few examples of such research in a few of the fields.

Pasture and Meadow Irrigation

In areas of low rainfall irrigation of pastures and hayland has long been a standard practice; in other sections of the country, however, supplemental irrigation of pastures is a new development and much important research work in this field is now under way.

The Georgia station found that supplemental irrigation on a Bermuda grass-Ladino clover pasture increased the dry forage 27 percent and the protein 67 percent. However, this heavier yield called for increased fertilization, especially with nitrogen.

At Dixon Springs the Illinois station (coop. USDA) found that a pasture irrigated seven times with 2-inch applications during the 1951

season carried 50 percent more animal units per acre and produced a 70-percent increase in animal gains over a similar nonirrigated pasture.

Irrigation can be effective even when rainfall is normal. The Kentucky station reported that during the 1951 grazing season central Kentucky had a deficit of only 3.75 inches of rainfall but a nitrated pasture that received seven 1-inch applications of water produced 5,300 pounds of dry matter per acre, whereas an untreated pasture yielded only 3,000 pounds of dry forage. Dairy cows grazed on the irrigated pasture produced almost 3,000 pounds more milk per acre than those on the untreated pasture.

Water needs for bluegrass pasture were determined by the Missouri station during periods of the growing season when moisture was adequate and the grass was making vigorous growth. Consumption rates were found to be 0.14 to 0.15 inch per day. Data such as these will enable the farmer to determine how much supplemental irrigation is needed and when the water should be applied.

The effects of irrigation may be apparent beyond the year in which water is applied. The New Hampshire station found that a pasture irrigated in 1950 but not in 1951 contained 7 percent more legumes at the close of the 1951 grazing season than a similar pasture which was not irrigated in either 1950 or 1951.

The Tennessee station reports that rainfall during the summer of 1951 was less favorable than normal. A pasture consisting of a mixture of alfalfa, Ladino clover, and orchard grass was irrigated with 24.33 inches of water at a cost of about $60 per acre. Uniform grazing was available throughout the season and dairy cows grazed on the irrigated pasture produced 37 percent more milk than was produced by cows fed on an unirrigated pasture. This increased production represented a money value of $121 per acre, a gain of $61 above the cost of irrigation.

At the Nebraska station 5 months of good pasture for dairy heifers was obtained from an irrigated alfalfa, bromegrass, and Ladino clover pasture. Pasturing the cattle for this period saved 608 pounds of hay, 4,978 pounds of silage, and 83 pounds of grain per head. This amounted to a saving of $28.45 per animal; the return on the pasture was $50.91 per acre.

In the Western States excessive irrigation of high-altitude mountain meadows has resulted in reduced yields of poor quality hay, with a low protein content. The Colorado station has shown that on such meadows the addition of phosphorus increased legume production when the meadows were not excessively irrigated. This work has demonstrated that mountain meadow hay yields probably can be more than doubled by fertilization and improved water management. This may have an important bearing on the livestock industry which has, in the past, depended greatly upon overgrazed national forests for feed during the spring, summer, and fall months.

Range and Pasture Establishment and Management

The successful production of forage crops depends, to a great extent, upon establishment and management methods. Recent research

has developed seeding and management practices that have aided in better and more efficient production, not only of new species and varieties, but of many older and better-known hay and pasture plants.

In a comparison of native and seeded rangeland the Colorado station found that beef production can be at least doubled by the use of seeded pastures. Pastures seeded to tall wheatgrass, Russian wild-rye, intermediate wheatgrass, and crested wheatgrass produced from 2 to 5 times as much beef per acre as native range and had a grazing capacity of from 2½ to 6 times that of native range.

A study of pasture mixtures by the New York (Cornell) station revealed that the addition of a third species to a pasture or meadow seed mixture increased the forage yield only when the third species (1) provided quick, early growth, (2) increased the yield the first crop year, and (3) persisted, and increased the yield in later years. Lack of moisture and fertility were found to be the major causes of seedling failure. Two considerations should be kept in mind in determining the most advantageous time of seeding: (1) Whether there is sufficient moisture to insure the germination and establishment of the pasture; and (2) the degree of establishment that is likely to be obtained prior to periods of hazard such as drought or heaving frost.

The ability of a tall fescue-Ladino clover mixture to afford year-round grazing was demonstrated at the Georgia station (coop. USDA). Rotational grazing made it possible to harvest a seed crop, produce quality hay, and accumulate a winter reserve equivalent to an amount of feed sufficient to carry one producing cow per acre every day of the year. Cows not given supplemental feeds produced 6,000 pounds of milk in a year even though the winter included a period of 90 days with an hourly mean temperature of 35° F.

Studies on seed production of native range grasses at the New Mexico station (coop. USDA) indicate that harvest of black grama grass seed should be delayed until the end of the growing season in order to take advantage of the higher set of seed then obtained. This study also showed that grama grass plants grown under lattice gave 42 percent greater seed set than open-grown plants. This indicates that large-scale seed production might be increased by planting black grama in altenate rows with taller plants which afford partial protection from drying sun and wind.

Band seeding of forage crops, a method developed by the Ohio station, has shown great promise. Good stands of ordinarily weak seedling legumes, such as birdsfoot trefoil, can be obtained by drilling the seed at 7-inch intervals with small spring grains spaced 14 inches apart in the rows. When this practice is followed the quantity of legume seed needed is reduced by one-third and weed competition is practically eliminated.

In a 10-year grazing study at the South Dakota station it was found that beef cows on a heavily grazed pasture lost weight and went into the winter in thin condition, whereas cows on lightly grazed pasture gained weight. Under heavy grazing the higher-yielding, more palatable taller grasses were replaced by short grasses, which resulted in a decline in range condition, forage production, and carrying capacity.

The Vermont station has found that birdsfoot trefoil is an excellent legume on heavy clay soils where alfalfa and Ladino clover make poor growth. Excellent stands are obtained with as little as 2 pounds of

seed per acre when it is drilled in alternate rows with various grasses. The acreage of birdsfoot trefoil in Vermont has increased from 0 to 3,000 acres in the past few years.

Tests at the Virginia station showed that rotating pastures and grazing them for periods of 4 to 6 days at a time resulted in a greater persistency of milk production by animals thus pastured. Based on a standard of $5 per hundredweight, milk produced by cows on Ladino clover-orchard grass pasture produced milk valued at $163.75 per acre.

The Wyoming station found that the grazing capacity of pastures seeded to crested wheatgrass, either alone or with alfalfa, was 72 sheep days per acre. Good native range had a grazing capacity of only 36 sheep days but when the native range was pitted with an eccentric disk the carrying capacity was 40 sheep days. Crested wheatgrass produced 45 pounds of lamb per acre, pitted native range 22 pounds, and nontreated native range 15 pounds.

Forage Crop Fertilization

Adequate fertilization is as necessary for efficient and economical production of forage crops and pastures as it is for row crops and cereals. The use of fertilizer on pastures and hay crops has increased markedly during the past few years and the putting into practice of results obtained in research on forage crop fertilization has greatly increased the value of these crops.

The Alaska station has found that the major nutrient deficiencies limiting yields of most crops are nitrogen and phosphorus. Fertilizer applications of 100 to 150 pounds of available nitrogen and 60 to 80 pounds of phosphorus can be expected to produce 2½ to 3 tons of 20-percent protein bromegrass hay in a favorable season. It has been demonstrated that Alaskan farmers get greater returns on their fertilizer investments when heavy applications are made. Small applications (20 to 40 pounds of nitrogen per acre) are practically worthless.

Although more attention is being given to the effect of nitrogen applied to forage crops than to the other required elements, information is needed on the response of various species to potash and phosphorus fertilizers. The Massachusetts station has found that timothy requires higher levels of phosphorus than orchard grass or smooth bromegrass but that its requirements for potassium are lower. It was also found that Ladino clover yields were increased by the use of potash, and that plots that were low in potassium killed out completely within 2 years.

The Mississippi station found that annual applications of phosphorus and potassium to a Dallis grass-white clover-lespedeza pasture maintained a more balanced relationship between the major species than biennial or triennial applications. In the same study it was learned that nitrogen applications on grass-legume combinations resulted in a better proportion of grass to legumes and thereby reduced bloat hazards.

A striking example of the economic value of applying fertilizers on dairy farms is shown by a study made at the Vermont station. Farmers who used no commercial fertilizer obtained hay yields of 1 ton per

acre, kept 15 cows, and had labor incomes averaging $370, whereas farmers using an average of 130 fertilizer units per acre obtained hay yields of 2 tons per acre, kept 24 cows, and had labor incomes averaging $1,346.

Many ranchers are interested in increasing the productivity of old dry-land seeded pastures. A study at the Wyoming station has shown that this can be accomplished through fertilization. Ammonium nitrate was applied at rates of 100, 200, and 300 pounds per acre to pastures of western wheatgrass, Russian wild-rye, and crested wheatgrass. The hay yields obtained were 1,100, 2,320 and 3,116 pounds per acre, respectively. Check plots receiving no fertilizer produced only 700 pounds per acre. Furthermore, nitrate applied in the spring of 1950 materially increased the seed yield of Russian wild-rye in 1951.

Value of Improved Pastures and Ranges

Research at the State experiment stations provides many examples of the value of better forage crops and improved pastures and rangeland. These benefits are not confined to the greater cash returns on the forage produced. They are also reflected in the increased production of beef, milk, and other animals products on the part of animals grazed on improved pastures and the increased animal carrying capacity of such pastures.

Experiments at the Indiana station show that a renovated bluegrass pasture which has been seeded to Ladino clover and birdsfoot trefoil will give greater beef production per acre than a bluegrass pasture that has received up to 400 pounds of nitrogen per acre per year. The experiment demonstrates conclusively the value of legumes in a pasture mixture.

Grazing trials at the Mississippi station, in which dairy cows were used, revealed that a permanent pasture of Dallis grass and white clover grazed from March to October will provide 67 percent of the total nutrient intake at a cost of 42 cents per 100 pounds of 4-percent fat-corrected milk. Johnson grass-red clover pastures provided the same nutrient intake but the cost was $3.93 per 100 pounds of 4-percent fat-corrected milk.

Pastures in southeastern Oklahoma, established at a cost of $10 to $15 per acre and fertilized annually at a cost of $5 to $10 per acre, are producing 200 to 500 pounds of beef per acre, according to data presented by the Oklahoma station. Unimproved pasture in the same area produced a maximum of 50 pounds of beef per acre.

The influence of a legume in a pasture mixture has been strikingly shown in a grazing test at the South Carolina station. Milking cows were grazed on a Kentucky 31 fescue-Ladino clover pasture for 222 days. The forage yield totaled 1,692 pounds of total digestible nutrients per acre equivalent to 1.97 tons of lespedeza hay. In the same test milking cows were grazed on an Alta fescue-Ladino clover pasture for 231 days. The forage yield averaged 2,598 pounds of total digestible nutrients per acre—equivalent to 3.02 tons of lespedeza hay. The difference in the production of the two pastures is accounted for by the difference in the amount of Ladino clover in the pastures—75 percent of the stand in the Alta fescue-Ladino pasture and 25 percent of the stand of the Kentucky 31-Ladino pasture.

The Vermont station, in a test in which Ladino clover was used for poultry range, found that each acre of pullet range saved about 1,150 pounds of purchased feed a year. At a capacity of 500 birds per acre the range-reared pullets consumed 2.3 pounds less feed per bird. This was a saving in purchased feed of 7.2 percent. This saving more than offset the costs of range shelters, of water piping, and of moving the birds to and from the range. It was also found that the range-reared pullets were more uniform, had firmer muscling, and carried a deeped pigmentation. Ladino clover was superior to bluegrass-orchard grass range because it yielded more, was more palatable, and was capable of a greater carrying capacity.

IMPROVEMENT IN FRUIT PRODUCTION

New developments in fruit production research are necessarily slow because of the nature of the material with which the scientific worker is occupied. An apple tree, for example, requires several years to reach profitable bearing age and, because of its slow development, cannot be profoundly modified in any single year by changes in management. However, research results accumulated over the years have brought about great changes in such orchard practices as soil management, pruning, nutrition, and spray or dust protection. Better machinery such as tractors, sprayers, and dusters in the orchard, and improved grading and handling devices in the packing shed, have aided in making fruit production a more business-like industry. There is still a lot of hard manual work with fruits, especially small fruits, that tends to limit production despite the demand for more and better fruit. The perishable nature of fruit is obviously a handicap to complete mechanization of the industry.

New Varieties

Ruby, a new apple so named because of its brilliant red color, was announced in 1952 by the Ohio station. It is a product of almost 30 years of research and trial by the station. From its parents, Gallia Beauty and Starking, Ruby derived certain desirable characters, such as good quality, a tendency to annual bearing, heavy productivity, and late maturity. Ruby fruit keeps well in storage and is not as susceptible to scald as its Gallia Beauty parent.

In search of a better McIntosh apple, the Massachusetts station evaluated carefully seven strains of this well-known variety and reported that the Rogers strain is the most desirable type and keeps somewhat longer in storage than the other six strains.

Based on good performance in the station trial orchards and in plantings of cooperating growers, five new grape seedlings were named by the New York State Station at Geneva and then turned over to the New York State Fruit Testing Association for propagation and distribution. Of the five new grapes, Himrod and Romulus are white, early, and seedless. Alden is a reddish-black grape with large oval berries, meaty in texture, and sweet and vinous in flavor. Bath, black in color, juicy, sweet and free from foxiness in flavor, is highly productive. Naples, of a color and flavor similar to the well-known Delaware, is superior to that variety in size of cluster and berries, and is less subject to cracking of fruit upon reaching maturity.

New Leads on Nutrition of Fruit Plants

Added evidence of the beneficial effects of mulch on apple trees was obtained at several of the State stations. At the New Hampshire station, apple trees which had been mulched for a period of 11 years without any additional nitrogen produced 150 bushels more fruit per acre than trees receiving only commercial fertilizer. Apparently after a few years of continuous mulching, yields may continue on a high level without further fertilizer applications, and thus save money for the grower. Furthermore, hay mulches were helpful in reducing leaf scorch, a trouble associated with magnesium deficiency.

Information obtained by the Missouri station revealed some of the reasons for the superiority of mulch culture. By sampling the soil beneath straw, hay, and sod, the workers found that the potassium content was significantly higher under the mulches. Twice in the 1951 season, soil moisture was depleted under sod but remained at near-field-capacity under mulches. Under mulch, small feeder roots were abundant on the soil surface and even penetrated into the mulch itself.

Foliar nutrition—the feeding of the tree by application of nutrient-containing sprays—continued to receive considerable attention. At the New Hampshire station, radioactive phosphorus was used in a spray for young apple trees in an effort to learn more about the intake and distribution of the absorbed nutrients. The phosphorus was found to be quickly absorbed by the foliage and translocated to all parts of the tree. On mature trees similarly sprayed activated phosphorus was also absorbed rapidly—much sooner than where the phosphorus was applied on the soil.

The Vermont station applied urea sprays in a commercial McIntosh apple orchard and reported increased yields of larger and better colored fruit.

Greenhouse and laboratory studies of urea absorption and metabolism in the apple leaf, using radioactive urea, were conducted by the New York (Cornell) station. These studies further confirmed earlier observations that urea enters the lower surface of the apple leaf more readily than the upper. A rapid movement of the absorbed material, or compounds formed from it, to other nearby leaves was noted. Analyses of the sprayed leaves indicated that within 96 hours, a large part of the absorbed urea was either converted to protein or translocated out of the leaves.

Successful production of peaches growing under a sod system of culture is possible, according to the Ohio station, if an adequate amount of nitrogen is supplied to the soil. This could lead to the culture of peaches on hillside sites that were heretofore considered unsuitable because of danger from erosion if the soil is maintained under cultivation.

Greatly increased crops of everbearing types of strawberries were obtained at the Iowa station by a combination of summer mulching and runner removal. Yields ranging from 10,000 to 13,000 quarts per acre were recorded the first summer from April-set plants treated in this manner as compared with less than 3,000 quarts for the usual matted-row method grown without mulch or runner removal. The

plants were set in beds of three rows, 1 foot between rows and 1 foot between plants in the row. The Iowa results confirm those reported earlier by the Ohio station at Wooster.

Contrary to unfavorable reports from growers, the Delaware station found that poultry manure can be effectively utilized in strawberry production, provided it is applied the autumn before the plants are set. Plots on which fall applications of poultry manure were made in most cases, outyielded check plots or plots manured directly before setting the plants. Manure applied at setting or used as a side dressing later actually killed some of the plants and promoted overvegetative growth. In view of the abundant supply of poultry manure in Delaware, the findings have great importance to fruit growers.

Controlling Fruit Set

Under favorable cultural and environmental conditions, most fruit trees such as apples, pears, peaches, and plums have a tendency to set too many fruits, with the result that the individual fruits are small and less valuable for marketing. Furthermore, in the case of the apple and pear, overproduction in one year tends to curtail fruiting the next year and in many varieties the trees fall into a production status known as alternate bearing. Removal of a part of the large crop at the proper stage of development, and timely feeding of the trees, tends to reduce the alternate bearing habit as well as to improve the market quality of the fruits that remain after thinning. Hand thinning will accomplish the goal, but this method is slow and costly. Thus for several years, the State and Federal research horticulturists have been greatly interested in chemical sprays for removing the excess flowers on fruit trees.

Comparisons at the Missouri station of dinitro-ortho-cyclohexylphenol and naphthaleneacetic acid sprays on Golden Delicious apple blooms showed in general that the latter chemical is the better thinning agent. Detailed observations on the effects of naphthaleneacetic acid showed that there was greater dropping of fruit from shaded than from exposed branches, from weak than from strong spurs, and from 1-year-old twigs than from older twigs. The maximum effect of the naphthaleneacetic acid spray occurred 3 to 4 days after application and on the second natural drop.

At the Idaho station, work with peaches showed the desirability of concentrations of 50 to 58 parts per million (p. p. m.) of naphthaleneacetic acid, when sprayed on the trees 5 weeks after full bloom. The spray prolonged the period of fruit drop instead of intensifying it during the normal drop period.

Maleic hydrazide was tested by the Michigan station for the thinning of peach fruits. Different limbs on the same tree were treated with concentrations of 425, 450, 475, and 500 p. p. m. and a good percentage of thinning was obtained. However, some hand thinning was necessary as a follow-up. Where vitamin K was used in conjunction with naphthaleneacetic acid to test the correlation that might exist between these two growth-regulating compounds, some evidence was observed that vitamin K has an antagonistic effect on the naphthaleneacetic acid.

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Rootstock Problems

Rootstocks may have a direct bearing on the size of trees, their resistance to low temperatures and certain diseases, and the time they come into profitable fruiting. From an economical standpoint, smaller trees are desirable since they are easier to prune, spray, and thin, and the fruit from them can be harvested at a lower cost than from large trees. One obstacle to the general use of selected rootstocks has been the difficulty involved in obtaining reliable dwarfing stocks due to the fact that proper techniques for identifying the various rootstocks have not yet been developed. A commercial planting of apples on dwarfing stocks was established at the Michigan station in 1945 with trees set 15 x 20 feet apart. This orchard is already in production and the trees are not yet competing with one another for space.

That all apple varieties cannot be successfully grown on specific rootstocks was shown by the Indiana station. For example, a definite incompatibility was found to exist between Golden Delicious scions and Virginia Crab rootstocks. Observations in an 11-year-old dwarf apple orchard showed Malling type I to be a promising rootstock for several scion varieties. To date, trees on this stock have produced twice the fruit obtained in a comparable orchard on commercial seedling rootstocks.

Where low temperatures are a problem, the South Dakota station reported that the best results were obtained by using Dolgo and Hibernal scions on Siberian Crab rootstocks as hardy framework stocks for top-working apple trees. The New Hampshire station found that *Malus sikkimensis* is a promising foundation stock for producing McIntosh, Northern Spy, Golden Delicious, Macoun, and Cortland apples.

As a means of reducing fire-blight damage to cultivated pears and new pear seedlings, the Ohio station has used successfully the resistant Old Home pear as the framework for trees.

Storage and Handling

The new fruit hormone 2,4,5-trichlorophenoxypropionic acid (2,4,5-Tp), used to delay the dropping of ripening apples, was observed by the New York (Cornell) station to have a stimulative effect on respiration and ripening of the fruit. However, by adding 100 to 200 p. p. m. of maleic hydrazide to the hormone spray the stimulus to ripening was reduced without decreasing the holding qualities of the fruits.

As a result of Cornell station work on the purification of air in apple storages with the activated carbon, four to six new carbon-controlled storage plants are being erected in New York each year. One was also built in Vermont and one in New Hampshire. In the spring of 1951, apples from carbon-controlled storages commanded a premium of up to $2 a bushel over regular cold-storage fruit.

That time of harvesting is an important consideration in the storage of apples was shown by the Ohio station. Rome apples suffered less superficial scald in storage when the fruits were allowed to ripen properly on the trees. It was estimated that approximately 160 days should elapse from full bloom to harvest.

Studies in progress at the Oregon station show that Anjou pears withstood satisfactorily a storage temperature of 28° F. inside the packed box. The fruits held at 28° softened more slowly and yellowing was greatly retarded. Fruits removed from 28°-storage after several months developed a satisfactory texture and flavor. However, a low temperature, the station reports, is practical only with reliable controls and adequate air circulation.

FARM FORESTRY INVESTIGATIONS

In many parts of the Nation, the farm forest is a highly important factor in the economy of the farming enterprise since it supplies fuel wood, fence posts, farm lumber, and occasional sales of marketable timber. In the winter and off-season periods, the farm forest can provide a profitable outlet for farm labor and enable the owner to maintain labor on a permanent rather than a seasonal basis. Although the silvicultural principles that apply to large forests also supply to the small farm forests, there are necessary adaptations. The farmer cannot employ skilled foresters nor can he utilize economically the large machinery that is associated with extensive forest operations. The professional foresters of the State stations recognize the farmer's problem and are endeavoring to help him solve it.

North Carolina station foresters found that burning is a necessary prerequisite to the successful regeneration of pond pine. On the unburned area only about 30 pond pine seedlings were recorded per acre, but in contrast an average of some 34,000 seedlings were counted on areas burned but not logged. Areas burned after logging had more seedlings than areas burned over before logging. Continued studies are in progress to determine proper season for burning, mimimum intensity of fire required, and other pertinent factors.

That fires may be a definite hazard in the oak stands in Missouri was revealed in a study by the station foresters of the nature of defects in oak logs. Fire wounds caused the most loss of all the causes of hidden defects, and white oak showed more of such injuries than did black or scarlet oaks. The Missouri station also investigated the value of different chemicals in the killing of inferior species of trees in the farm forest. Applications of Ammate to stumps were more effective in summer than in winter.

Foliage sprays with both 2,4,5-Tp and Ammate were rather ineffective in preventing resprouting, even though apparently effective in killing the original growth. Frill applications of both Ammate and 2,4,5-Tp were very satisfactory in killing certain species.

Studies conducted by the Minnesota station (coop. USDA) have revealed significant differences in the growth rate and growth habit of jack pines grown in northern Minnesota from seed collected in different locations in the jack pine range. The discovery of superior strains of forest species, such as jack pine, would mean more productive farm plantations and greater returns to the grower.

At the Michigan station flats and bands cut from cottonwood lumber at veneer plants were treated with 11 different wood preservatives in an attempt to increase their durability. Flower and vegetable seeds were sown later in the treated receptacles, and records were kept on the performance of the resulting plants. Preliminary findings show

that water-soluble preservatives were less harmful to the plants and less costly than the organic solvent materials. Treated wooden receptacles were less toxic to plants, if thoroughly dried before being put into service.

The possibility of more profitable maple sugar production was suggested as a result of studies conducted by the Vermont station. Trees were shown to differ in the percentage of sugar in their sap and although there was some annual change in the trees studied, high-sugar trees maintained their relative position year after year. Furthermore, maple trees were found to vary in amount of sap excreted and in rate of flow of the sap. This information should aid in the isolation of potentially valuable trees and should lead ultimately to the establishment of maple groves of superior type.

VEGETABLE CROP RESEARCH

Vegetable crop research in many different forms has been carried on at the State experiment stations. Studies in mechanization of vegetable growing operations have developed information that has helped to take a part of the "stoop" and hand labor out of gardening. This is of special economic significance to commercial growers, and has also added materially to the satisfactions and returns of home gardeners. Small motor-driven garden equipment has become extremely popular; new methods of fertilizer and spray application are under study; and better harvesting and storage methods are evolving. The breeding of new vegetable varieties to meet modern requirements continues. Leaders in vegetable crop research are cooperating closely with entomologists and plant pathologists in developing new scientific methods for the control of insects and vegetable diseases, and with the agricultural engineers and economists in developing improved spraying and harvesting equipment and storage facilities. Selected examples of the results of research in the fields mentioned follow.

Vegetable Culture

Foliar fertilizer applications

The effect of spraying greenhouse tomatoes with nutrient solutions has been reported previously. The Michigan station now reports the results of spraying the leaves of certain vegetables with fertilizers. Tomato, bean, and corn plants grown at low phosphorus levels gave definite growth responses to foliar-applied phosphorus, as indicated by height and fresh weight measurements. Early yields, but not total yields of field tomatoes were increased significantly by four weekly sprays of a 25-millemolar solution of *o*-phosphoric acid. Considering the quantities applied, foliar-applied phosphorus was utilized much more efficiently than phosphorus applied broadcast to the soil; but the latter treatment gave the highest total yields.

Tracer studies with radioactive *o*-phosphoric acid have demonstrated that foliar-applied phosphorus is rapidly absorbed by the leaves of the tomato, corn, bean, and squash plants and is translocated to the root tips and other centers of high metabolic activity.

At the Maryland station foliar fertilizer applications have been effective in increasing the yield of tomatoes when the applications of

fertilizers have been added to fungicide sprays to control premature defoliation. Increases up to 2.35 tons per acre have been realized where borax or borax plus magnesium sulfate have been added to the fungicide.

Turnip-seed production

At the Idaho station attention has been given to the problem of the winterkilling of fall-planted turnips intended for seed production the following summer. It was found that plants obtained from turnip seed planted in the bottom of listed furrows at any time between August 20 and August 31 would survive even under conditions of severe freezing and thawing. Planting in the listed furrows provided protection from the winter sun's rays, dessication by wind, and from intense cold under a poor snow cover, as well as a support for the tops of the turnips which, in turn, provided an insulating effect against low soil temperatures at the base of the plant.

Mushroom production

At the Ohio station mushroom yields were increased up to 50 percent when vitamins were added to mushroom beds. Additions of riboflavin, niacin, thiamine, and pantothenic acid each resulted in increased yields, but the greatest yield came from a combination of all four vitamins. Chemical assay of the mushroom crop grown in the treated beds did not show any significant increases of vitamins, but the increase in yield alone permits a profitable production of 2 pounds of mushrooms per square foot of bed.

Row spacing

In connection with its efforts to obtain greater efficiency of operation the vegetable industry is becoming increasingly aware of the need for better land utilization. To that end more effort is being given to obtaining maximum yields from minimum acreage. Within the past year several States have reported on the effect of closer spacing on yield.

The Georgia station has completed a study to determine an improved method of spacing asparagus. Rows were spaced 5 feet apart, with spacing between plants of 12, 18, 24, 30, and 36 inches. It was found, in a 7-year test, that the yield and number of spears per acre decreased as the distance between plants increased. The highest yield was obtained from the 12-inch spacing.

In research at the Utah station, yields of Clarks bush lima beans were significantly increased when the width between rows was reduced from 24 inches to 12 inches. No significant difference was observed when the rows were 12, 16, or 20 inches. With the dwarf variety Utah 16, however, the 12-inch spacing of rows resulted in a profitable increase. Incidentally, Utah 16 surpassed in yielding ability the commercial varieties with which it was tested.

Broccoli has been the subject of a spacing experiment at the California station. Work with five varieties has shown that the highest yield of sprouting broccoli results from a spacing of slightly more than 8 inches, whereas in a 12-inch spacing total yields were reduced significantly even though head and stem diameters were greater than at the 8-inch spacing.

The Utah station (coop. USDA) has found that closer spacing than is normally practiced combined with a satisfactory supply of soil moisture may result in greater profits in growing onion and carrot seed in that State. As a result of this research, information on land and water economy is now available, that will be of great economic help to the seed-growing industry in Utah and other Western States.

Controlled water for vegetable crops

The value of controlled irrigation and proper soil management in securing maximum yields for many vegetable crops is reflected in research dealing with the yellowing in early spring lettuce, as carried on by the Arizona station in the Salt River Valley. The yellowing is considered a physiological condition and causes sizeable losses to the growers of head lettuce in various part of the country. Untimely irrigation applications are largely responsible for this physiological condition. The station has shown that proper soil management practices will prevent soil aeration and compaction.

At the Florida station irrigation studies with cabbage, sweet corn, snap beans, onions, tomatoes, and cucumbers have revealed that under certain conditions, supplemental irrigation may result in increased profits during a period of deficient rainfall. In some years supplemental irrigation showed no advantage, but in other years irrigation was responsible for the difference between a successful harvest and crop failure.

The Utah station recently published results from irrigation and fertilizer trials with sweet corn. These findings indicate that additional nitrogen is beneficial to sweet corn when it is accompanied by additional moisture. Up to 200 pounds of nitrogen per acre were beneficial and the nitrogen applications gave the maximum yields when adequate moisture was present.

Harvesting and Storing Vegetables

A survey reported by the California station points out how improved methods of harvesting canning tomatoes can result in immediate reductions in labor requirements and cut costs by 20 to 30 percent. It is estimated that the economic value of such methods in the United States as a whole in the 1951 season, when the tomato harvest for processing reached about 2½ million tons and required the employmen of some 50,000 pickers, would have been approximately $5,000,000. This survey covered various subjects—the type of tomatoes planted, the method of harvest, method of handling, kinds of containers, field lay-out, number of pickings, and the type and availability of labor in connection with the harvesting process. Although of a preliminary nature, this report points the way to greater economies through a greater utilization of mechanized harvesting.

At the New York (State) station the tenderometer has been shown to be a valuable instrument for determining the best time to harvest peas for canning and freezing to secure a high quality product and thus realize maximum financial returns. The tenderometer is a mechanical device which measures the resistance of peas to a shearing force in terms of pounds per square inch. The higher the tenderometer value, the harder, and, therefore, the less desirable and lower

grade are the peas. The best returns can be realized when the crop is harvested by grades rather than by yields. Quality rather than quantity is the determining factor in accepting vegetable produce, and the peas that are young and tender command a higher price in the market.

The California station has found that storage temperature has direct bearing on the storage life of summer squash. Squash remains in marketable condition for about 14 to 17 days when stored at 32° F., for 14 days at 50°, for 8 days at 60°, and for only 6 days at 70°. Observations were made of the appearance of fruits during the storage periods, and the changes in chemical composition were studied. Fruits of Early Prolific Straightneck summer squash were used to determine the quality changes in squash shipped to distant markets at various temperatures.

Testing New Varieties

In carrying on vegetable variety research it is necessary not only to develop new varieties, but also to test these varieties under various environmental conditions before they can be recommended to the seed trade and the public. A number of State experiment stations devote special attention to the testing of new varieties from nearby and distant States. These trials generally are cooperative among different stations and between them and the Department of Agriculture.

An outstanding example of cooperative vegetable research is that done through the United States Vegetable Breeding Laboratory at Charleston, S. C. The program is a cooperative one between the Department and State experiment stations, particularly in the South. One specific phase of this work is that concerned with the improvement of tomatoes. Known as the Southern Tomato Exchange Program (STEP), specialists from the laboratory and from southern and other experiment stations attack breeding problems as a team. Promising varieties are exchanged for trials at the different locations prior to release to growers, the seed trade, and commercial and home gardeners.

The Northeastern Cooperative Trials, another agency for testing varieties, uses the facilities and services of research workers at the State experiment stations in the northeastern region.

Among outstanding State experiment station trials are the ones conducted by the Pennsylvania station which, in 1951, grew and evaluated 15 eggplant, 9 rutabaga, 33 garden pea, 73 tomato, 53 snap bean, 27 cucumber, 110 sweet corn, 23 beet, and 21 carrot varieties and strains. Detailed records of the trials are published and have been made available to the public. On the basis of observations in trials made at different locations in the State, the New York (Cornell) station since 1934 has issued 15 reports on the newer varieties of vegetables for the guidance of home and commercial gardeners.

Green-sprouting broccoli

From the Texas station a new variety of green-sprouting broccoli has been announced under the name Texas 107. This variety is noteworthy because of its high production of marketable side shoots.

When evaluated with available commercial varieties Texas 107 is usually superior in earliness, evenness of maturity, and quality of head. Yield data indicate that it is best adapted to production from fall planting.

A new celery

Eighteen years of effort at the New York (Cornell) station has culminated in the introduction of a new blight-resistant celery that has been named Emerson Pascal. The new celery is the green type which is currently in great demand on the market. It has excellent table quality and crisp, fleshy stalks. In all but areas most heavily infested with blight fungi, spraying to control this disease is not considered necessary. Its immunity to fusarium yellows disease adds to its worth for successful production.

Emerson Pascal celery was named after a famous plant breeder, the late Prof. R. A. Emerson, who helped to develop it at the New York (Cornell) station and who encouraged the cooperative effort that is woven into the history of this new variety. Factors from world-wide sources entering into the ultimate development of Emerson Pascal—the findings of a graduate student at Cornell University from India, seed from a leaf variety of celery from Denmark, and suggestions made by a keenly observing scientist with the Eastern States Farmers Exchange in Massachusetts. Several plant breeders at the New York (Cornell) station aided in the long and painstaking effort to develop the variety. During the testing phase, cooperative efforts in Florida on the part of both the Everglades and Central Florida Branch Stations, as well as on the part of commercial growers, particularly in Wayne County, N. Y., contributed much to bring about the introduction of this new celery.

Improved Vates kale

A new strain called Improved Vates kale with shorter leaf stems has been developed at the Virginia Truck Experiment Station. Damage caused by strong winds blowing over the fields of maturing kale present a new problem to plant breeders at the Viriginia Truck Station. The new strain is a more compact and lower-growing plant that will stand up under winds that cause damage to the older Vates variety. Yield from the new strain is not expected to equal that obtained from the older kind, but closer planting and improved culture are expected to compensate and give an equal or better yield on an acre basis.

Lettuce varieties

The Michigan station won a signal honor when the All-America Selections (A. A. S.) of the American Seed Trade Association named Great Lakes lettuce as one of the 10 best all-time All-America vegetable winners originated since the establishment of the A. A. S., 19 years ago. This variety, developed by the Michigan station (coop. USDA), is perhaps the most widely grown head lettuce in the United States. Its great popularity comes from its high quality, its ability to stand a long time without bolting. and its remarkable resistance to tip-burn.

Through the efforts of plant breeders at the South Carolina station (coop. USDA) a profitable industry in that State may be reestablished. This station has introduced new mosaic-resistant cos lettuce, named Parris Island. Growers in South Carolina recall the success of the earlier cos or romaine lettuce varieties that were in demand 20 years ago. A virus disease, known popularly as mosaic, wiped out this industry in South Carolina. Now, with a new mosaic-resistant variety available, a superior cos from the Carolinas may again appear on the market. Tests in both North and South Carolina evaluate Parris Island as a dark green type with a good head, equal in quality to the older varieties of cos and, most important, highly resistant to the virus disease that caused failures to this desirable type of lettuce in the past.

Delicious 51 muskmelon

The specter of a crop of muskmelons devastated by fusarium wilt is unlikely with the introduction of Delicious 51 muskmelon. This new variety, developed by the New York (Cornell) station, is similar in appearance, maturity, and quality to the standard Delicious, but carries resistance to fusarium wilt, a disease capable of destroying the entire crop once the soil becomes heavily infested. Delicious 51 is considered to be an earlier but companion variety to the popular Iroquois.

Onion hybrids

Further successes in the cooperative breeding program to produce superior, high-yielding onion hybrids are reported with the introduction of two new varieties by the Texas station (coop. USDA). Granex and Crystal Hybrid are the names given to these newcomers which have produced outstanding yields in Texas tests. Granex is a large, flat, light yellow onion, with an exceptionally mild flavor. Crystal Hybrid is a flat, white onion with a slightly more pungent flavor than Granex. A limited supply of seed will be available from commercial seedsmen for fall planting in 1952.

A new southern pea

Cream 40 is the name given to a new southern pea developed by the Texas station. It was produced from a cross between Extra Early Blackeye and a viny, midseason commercial cream variety. The new introduction combines the qualities of both parents, being early, long-podded, and a good yielder of quality peas that process well. In addition, the growth habit of Cream 40 makes it desirable for efficient harvesting. Its vininess is not excessive and occurs near the ground so does not interfere with harvesting by hand or mechanical means.

New sweet-corn hybrids

Brown silks on the interior of sweet corn have long been a problem to processors. The removal of these silks to insure a pleasing dish of sweet corn for the consumer is both laborious and costly. The Indiana station has developed a hybrid yellow corn yielding 10 to 15 percent more than Golden Cross Bantam and having white, rather than brown, interior silks. Golden Harvest, the name given to this new-

comer, has been tested for the past 2 years by Indiana canners and seedsmen who found the uniform golden color of the processed corn to be noteworthy. It is estimated that about 500,000 pounds of seed will be available for planting in 1953.

In 1953 the seed of New Jersey 101 is expected to be in good supply for growers of sweet corn. This new hybrid is from the New Jersey station and has been well tested in all stages from the producer to the consumer. New Jersey 101 grows about 6 feet tall and produces 9-inch ears with bright green husks and tight tips. It outyielded Carmelcross by about 30 percent. It is a medium-early, yellow-kernel variety that matures about 5 days earlier than Golden Cross Bantam.

New tomatoes

Growers in southern Florida are particularly enthusiastic over a new tomato named Homestead, developed and introduced through the Southern Tomato Exchange Program at the Vegetable Breeding Laboratory, United States Department of Agriculture, Charleston, S. C., in cooperation with the Florida station. The principal commercial trials of this variety were arranged and conducted at the Subtropical Experiment Station at Homestead, Fla., from which the name was derived. Growers in this area, where 12,000 acres of tomatoes are grown annually for green shipment to more northern States, are enthusiastic over the performance of Homestead on wilt-infested soil. It is highly productive under a wide range of conditions, with fruit maturing slightly earlier than Rutgers and averaging slightly larger in size.

Three new tomato hybrids have been reported within the past year from the Iowa station. Since 1947, it has been the aim of the station's plant breeders to develop hybrid tomatoes that would be of value to Iowa growers. After a breeding program, involving many of the popular tomato varieties grown in that State, three new hybrids have stood out on a basis of four seasons of testing, namely—Indiana Baltimore × Pritchard, Earliana × Jubilee, and Rutgers × John Baer. All three of these hybrids gave noteworthy yields of early crop fruit, and for the entire season they all exceeded in total yields the standard varieties with which they were compared. They also compared favorably in quality and size with their competitors.

Cavalier is the name given another tomato variety developed at the North Dakota station. It is a selection from a Bounty × Valiant and is reported to be superior to Victor and Bounty in both fruits and plant type. Its earliness is noteworthy.

Fusarium wilt, a disease that often causes large losses to tomato growers, may be less of a problem as a result of research at the Tennessee station. The Tucker tomato has been introduced at that station as a new wilt-resistant variety. This is the result of a selection from several lines obtained from the Missouri station in 1947. The line 6–S–17 was selected as outstanding and a selection from this line was finally chosen to be named Tucker.

FLOWERS AND OTHER ORNAMENTALS

In many parts of the country the business of growing flowers and ornamental plants is becoming an increasingly important economic

enterprise. Since World War II, with the great expansion of home building, proper landscaping of the home with locally adapted ornamental materials is being given considerable emphasis. Modern methods of transplanting, together with mechanical equipment available to contractors, make it possible to obtain within a few months' time the setting of lawns, trees, ornamental shrubs, and flowers called for in the blueprint. Increasingly, the nurserymen from whom the plant materials are purchased and the growers from whom the enthusiast obtains his ornamental flowers and shrubbery are relying on the specialists at the State experiment stations for development of new cultural and propagation methods and the breeding of new varieties. A few recently reported results from such research follow.

New Flowers

Two new outdoor chrysanthemum varieties have been named and introduced in the past year by the Minnesota station. Prairie Sunset is the name of the first variety which bears large, double rose-pink flowers; and Harvest Bronze, the second variety, bears double red-mahogany flowers which change to yellow as the flowers mature.

The Colorado station reports the development of four new carnation varieties suitable for growing under glass in many parts of the United States. The variety, Colorado Gold, has an orange-yellow color and produces a short, compact flower, and short, sturdy stems. The variety, Durango, is similar to Colorado Gold in general dimensions, but has a bright crimson color. Fanfare is a deep pink and grows somewhat taller than Colorado Gold or Durango. It has an excellent stem for flower arrangements in vases and bowls. The fourth variety, Serenade, is usually taller than the normal carnation. It is medium pink and produces a medium-sized flower. The variety is extremely vigorous and a heavy yielder when it has adequate water and nutrients.

Carnation Variety Honored

The carnation variety, Mrs. E. F. Guba, developed by the Massachusetts station and described by the trade as a "spectacular variety," won the first prize in its color class for the second successive year at the American Carnation Society Convention. The petals of this carnation are of an almond color with deep pink edges and lines. The flower is very large and full and is a remarkable keeper. It is reported by commercial growers to be a heavy producer, with long sturdy stems. Over the season it will produce up to 30 top-grade blooms per square foot of bench.

Liquid Fertilizers

For a number of years the New Jersey station has played an active part in research on the value of liquid fertilizers for ornamental plants in commercial production. Its findings have been adopted by commercial interests and home owners as well. During the past year additional work has centered on the nutrient requirements of potted poinsettias and hydrangeas. By the use of frequent fertilizing with small amounts of liquid nutrients favorable increases in the growth of these two plants have been obtained. Liquid fertilizer was found

to be more economical than dry fertilizer, and investigators found that it was possible to obtain with it more effective control of the color of the flowers on hydrangea plants.

The Effect of 2,4-D on Woody Ornamentals

The New York (Cornell) station has made a study of the effect of chemicals used for weed control on woody ornamentals. Occasionally there is a delayed damage when 2,4-D is used to control weeds growing in close proximity to shrubbery. It has been found, however, that damage can be minimized by September spraying of low amounts of 2,4-D in a single application at low pressure. Single winter treatments of 2,4-D purposely applied at low pressure to dormant deciduous shrubbery in amounts up to 1.6 pounds per acre failed to cause delayed injury to the shrubbery.

Improving Greenhouse Soils

Composite greenhouse soils have been under study at the Storrs station (Connecticut). Efforts were made to find organic materials that would equal or exceed cow manure in providing good tilth for soil in greenhouse benches. A 2-year study showed that the most effective materials were sawdust, peat, muck, cow manure, and sugarcane in the order given. The organic materials highest in cellulose, however, such as sawdust and sugarcane, resulted in an unbalanced nitrogen supply in the soil and adversely affected greenhouse crops. The findings indicate that under the conditions of the experiment, sawdust and sugarcane cannot be substituted for manures and peat.

At the Hawaii station various organic materials have been tried in connection with the growing of anthuriums. This ornamental plant, it is expected, will be a valuable addition to the floricultural markets of the Hawaiian Islands. The station reports that plants will grow well in macademia nut hulls, coffee parchment, and cane trash. Plants grown in leafmold, taro pulp, and treefern fiber do moderately well, but poor growth was reported when they were grown in volcanic cinders, soil, or wood shavings.

Understock for Junipers

The Ohio station has reported on the value of using various understock in grafting popular ornamental evergreens. Five scion varieties, *Juniperus virginiana burki*, *J. virginiana canaerti*, *J. virginiana hilli*, *J. chinensis columnaris*, *J. chinensis keteleeri*, were side grafted onto Eastern Redcedar, Chinese, Andorra, Irish, and Spiny Greek junipers, and Oriental Arborvitae. After 4 years of growth the resulting plants were compared over a period of 2 years. On the basis of plant survival, growth rate, and quality of top growth of the scion varieties, the understocks rated as follows: Eastern Redcedar, best; Chinese juniper, satisfactory; Andorra, Irish, and Spiny Greek junipers, fair to poor; and Oriental Arborvitae, poor.

The use of selected understock to cause dwarfing of evergreens has been reported by the Oklahoma station. Following 3 years of growth after grafting, it was found that four juniper species under test grew from 39 to 60 inches on nondwarfing rootstock, whereas on dwarfing

rootstocks they grew only one-third to one-half as high. For foundations and other plantings in restricted areas, the suppressed growth from dwarfing understock is frequently desirable.

SOIL SCIENCE

Important research contributions were made during the year in the fields of soil physics, soil chemistry, basic soil-plant relationships, and soil microbiology. Since it is not possible to review all of the research in these fields, that of microbiology is selected for major emphasis because of its timely significance. Other areas of soil science and plant nutrition will be reviewed in subsequent years.

The use of organic chemical compounds for the large-scale control of weeds, insects, and diseases brought a new problem into crop production, namely: What effect would these materials have upon soil productivity? If the new herbicides, insecticides, and fungicides have any effect upon crop growth, would this effect take the form of adverse action on the micro-organisms that normally inhabit fertile soils?

Experiments seeking answers to these questions have been conducted during the past 5 or 6 years. Their purpose was to learn what effect organic chemicals have on such important biological processes as the decomposition of organic matter, nitrification, and nitrogen fixation, all of which are intimately associated with crop production. The findings of some representative experiments along these lines are here summarized, as are certain of those in related fields of soils microbiology.

Effects of Herbicides and Insecticides on Soils

The Pennsylvania station found that 2,4–D has little, if any, effect on the process of nitrification in the soil as long as the rate of application is not excessively high. The same thing was true for phenyl mercuric acetate, another chemical used for weed control. Applications of 2,4–D, either in the form of the sodium salt or in the amine form, resulted in only temporary depressions in nitrification. The rate of nitrification returned to normal within a period of 2 weeks, although it was approximately 2 weeks longer before the last traces of the herbicide disappeared from the soil. The amine form had a slightly greater effect than the sodium salt in depressing nitrification.

A second application of either of the 2,4–D preparations reduced nitrification in much the same manner as the first, but recovery of the nitrification process took place in about the same length of time. The herbicide disappeared more rapidly, however, after the second treatment. When 25 parts per million of phenyl mercuric acetate was applied, complete recovery of nitrification occurred in less than 30 days, whereas with applications of 50 parts per million only partial recovery resulted in this period of time. When 100 parts per million were applied, there was little evidence of nitrification at the end of 30 days.

Nitrification studies at the Kansas station showed that applications of 3 and 10 pounds per acre of the sodium salt of 2,4-D reduced nitrate accumulation up to 4 weeks on a sandy loam soil. Applications of 25 and 50 pounds likewise reduced nitrates during the 4-week period. At the end of 8 weeks, however, the amount of nitrate nitrogen in

every case was, for all practical purposes, the same as in the untreated controls. On a silt loam soil 3 pounds of 2,4-D did not cause a significant nitrate reduction at any time during a 16-week period. Applications of 10, 25, and 50 pounds per acre reduced the rate of nitrification during the first 8 weeks, but only the 25- and 50-pound rates gave significant reductions during the second 8-week period.

The total number of bacteria in soils was not altered to any appreciable extent by applications of 2,4-D at ordinary field rates. On the other hand, applications of 25 and 50 pounds per acre on the silt loam soil produced temporary increases in the number of bacteria, lasting up to 8 weeks. The rate of decomposition of organic matter was not affected by the 2,4-D.

Maleic hydrazide, recommended as an herbicide under certain conditions, was found to be toxic to plant growth on several major soil types in California. Among the 11 soils studied, toxicity was highest and inactivation slowest in Arbuckle clay loam, 15 parts per million being toxic originally and 340 parts per million still causing complete sterilization 5 months later. Sterility to plant growth was obtained at 140 parts per million in 4 soils. Inactivation was fastest in Aiken clay loam, where 680 parts per million were not toxic 3 months after application. In Yolo fine sandy loam, 5,000 parts per million still inhibited all growth after 7 months.

Maleic hydrazide was held by the clay component of the Aiken clay loam soil, but moved freely with the soil solution in all of the other soils. As a result of these experiments, the California station concluded that maleic hydrazide in the amounts used would not constitute a hazard on most soils during warm growing weather. Although it can sterilize soil against plant growth when used in large enough quantities, it decomposes too readily under normal conditions to be considered an effective sterilant.

Three different phenyl mercuric compounds (the acetate, hydroxide, and triethanol ammonium lactate) were also studied at the California station. Applications of these compounds at the rate of 680 parts per million inhibited plant growth in the four soils used, and at 220 parts per million the reduction in yield was considerable. Under greenhouse conditions the chemicals had decomposed by the time of second cropping to such an extent in all instances that little toxicity was left in the soil, even at the highest concentration (680 parts per million). Leaching experiments showed, however, that 20 centimeters of water did not displace the thriethanol ammonium salt from the top layer of the soil.

No significant difference was found between the toxicity of pentachlorophenol (PCP) and its sodium salt. Over a period of 12 months neither of these compounds broke down appreciably in the soil under greenhouse conditions. The California scientists point out that this is in decided contrast to other organic chemicals. Because PCP is a potent fungicide, this failure of decomposition in warm moist soils may inhibit microbial activity or produce partial sterilization over a long period of time.

Leaching could possibly be relied upon to rid the soil of the toxic principle of PCP since the chemical is not fixed by the clay fraction. Large quantities of PCP, in the range of 600 to 1,200 pounds per acre of soil distributed to a depth of 1 foot, were found necessary to in-

hibit plant growth to any great extent. In practice, successful results are often obtained with less than 40 pounds of PCP per acre, indicating that the chemical is active in a relatively shallow soil layer. Since the amount required to be effective is so much less than that found to retard plant growth, it is concluded that there is little danger of harmful residual toxicity in the soil from the use of the usual field rates of applications of PCP.

Experiments with 2,4-D compounds at the California station show that little toxicity remained in the soil by the time of the second cropping, that breakdown of the materials was slower in neutral and alkaline soils than in acid ones, and that the fixation on the clay fraction was so pronounced that leaching with 320 centimeters of water did not free the soils of 2,4-D. The three forms of 2,4-D used acted alike when mixed with the soil, perhaps because the salt forms revert to the parent acid form through hydrolysis.

The Utah station found that DDT, chlordane, and benzene hexachloride (BHC) were still toxic to ammonifying and nitrifying bacteria in soils following a 3-year storage period. Although the inhibition of these bacteria was less than in the two previous years, all three materials showed toxicity in concentrations of 0.1 percent and above. The DDT content of the soil had declined, but the rate of breakdown was not as pronounced as between the first and second years.

The greatest percentage decomposition of DDT occurred in the soils with the highest content of organic matter, and at the lowest rates of application. The experiments showed that DDT is slowly decomposed by soil micro-organisms. Since the toxic concentrations of DDT, chlordane, and BHC are considerably higher than the recommended rates of usage, the Utah scientists believe that where these rates are not exceeded there is little or no reason to fear harmful results from accumulations in the soil. Another herbicide, aromatic solvent, did not injure either the ammonifying or nitrifying bacteria when added in irrigation water in concentrations as high as 2,400 parts per million.

Decomposition of Organic Matter

Plants grown at the Iowa station (coop. USDA) in an atmosphere of radioactive carbon dioxide were incorporated into the soil in order to determine the effects that green manure crops have on the decomposition (mineralization) of the organic matter already present in the soil. Corn and soybean crops were used, and the rate and extent of their mineralization were followed over a 6-month period by measuring the radioactive CO_2 produced. The breakdown process of the native soil organic matter was speeded up by the addition of the fresh crop residues, especially during the first few weeks following application. The rate of mineralization of the native soil organic matter was stimulated to the greatest extent in the soil with lowest organic matter content (Monona silt loam). Actually the rate of decomposition of the organic matter already present in this soil was almost twice as rapid following the incorporation of corn residues, as in the absence of the corn residues. Very little of the crop residues remained in any of the soils at the conclusion of the incubation period,

and only small increases occurred in the treated soils as compared with the controls where no residues had been added.

Until radio carbon became available for research it was not possible to distinguish between the newly added and the native organic matter in soils in decomposition studies. These experiments throw new light on the very important problem of loss of organic matter in soils, and confirm a belief held by many, but which could not heretofore be proved, that native soil organic matter "burns out" faster following the addition of a green manure crop.

The Oklahoma station found that plants take up more fertilizer N and less of the native soil N on soils low in organic matter than on soils of high organic matter content. Both ammonium and nitrate N, labeled with the N^{15} isotope, were used as fertilizer. Although the amount of N in the plants was about the same for both sources, there was a higher recovery of that added in the nitrate form. Residues from plants grown to contain N^{15} were added to soils in the greenhouse to determine the time and rate of biological release of N from the organic matter as measured by its uptake by growing oat plants. More of the N in the growing plants was derived from the added organic matter in the second harvest than in the first, indicating the importance of crop residues as a source of N during the growing season, provided conditions are favorable for biological activity.

The Oregon station found that the rate of decomposition of various tree products, when used as soil amendments, decreased in the following order: Pea vines, wheat straw, alder sawdust, ponderosa pine sawdust, cedar sawdust, Douglas-fir cork, Douglas-fir sawdust, young Douglas-fir bark, hemlock sawdust, old Douglas-fir bark. Cedar sawdust decomposed very slowly during the first 10 days. Water extraction increased decomposability of old fir bark but had an opposite effect on the young bark. Douglas-fir bark and fresh sawdust were slightly toxic to soil micro-organisms and plant growth, but this toxicity was overcome by the addition of available N. Various wood waste mulches harbored exceptionally high numbers of micro-organisms, whereas the underlying soil contained approximately the same numbers as unmulched soil.

The commonly observed reduction in carbon dioxide evolution, when N fertilizer is added to hasten the decomposition of crop residues, has been explained by experiments at the Oregon station. The addition of available N resulted in an increase in the number of organisms and a corresponding increase in CO_2 production, but for only 24 to 48 hours. This brief increase in CO_2 production has often been overlooked in the past. The larger population of micro-organisms naturally requires more carbon, both for energy and for building bodily protoplasm. For this reason more organic carbon is tied up when N is added than when it is not added. This carbon remains tied up for varying periods of time in the bodies of the micro-organisms. It is gradually liberated, however, as CO_2 but does not show up in the course of the usual 30- to 90-day respiration experiment.

A new product, Orzan (a dehydrated waste sulfite liquor byproduct of the paper industry), now available as a soil amendment, was found by the Oregon scientists to be decomposed in the soil in much the same manner as ordinary plant residues. The rate of nitrification of the product compared favorably with that of peptone, and its sul-

fur was oxidized to the sulfate form at about the same rate as was elemental sulfur. Orzan decomposed in the soil about one-third as rapidly as added dextrose, but 50 percent more rapidly than pine sawdust.

Utilization of Nitrogen by Soil Micro-organisms

Studies at the Iowa station (coop. USDA) using isotopic nitrogen (N^{15}) have further established the fact that ammonium N is preferred over nitrate N by soil micro-organisms. When both forms of N were present, the ammonium form was used almost exclusively. These findings help to explain why immediate recovery by crops from applications of ammonium N is nearly always low in comparison with recovery from a like amount of nitrate N. Soil microbes utilize the ammonium N, thus leaving less N for the growing crop. Nitrogen tied up in the bodies of micro-organisms is not lost from the soil, however, but becomes available upon their decay and then may be utilized by the growing crop or tied up again in newly synthesized cell materials. When the nitrate form is applied as fertilizer, soil micro-organisms use less of it, and thus more is available to the immediate crop and recovery is higher.

The preference of bacteria for ammonium N was also demonstrated in experiments at the Oklahoma station. After bacteria had become adapted to growing on nitrate N by prolonged culture on a nitrate medium and then were transferred to a similar medium containing the stable isotope N^{15}, it was observed that the nitrate (NO_3) in the medium disappeared within 24 to 36 hours. When ammonium nitrate was added to these cultures, the NO_3 continued to disappear at a rapid rate. The amount of ammonium N also decreased, but at a much slower rate. Increases in total cellular N were closely correlated with disappearance of the ammonium N from the culture.

Aeration of the cultures did not appreciably reduce the rate at which nitrate disappeared from the medium. The fact that N from the nitrate showed up only to a slight extent in the bodies of the bacteria is further evidence that the nitrate form of N is lost by denitrification under well-aerated conditions, and that bacteria prefer ammonium to nitrate N.

Loss of Nitrogen by Volatilization

Investigations on the loss of N from flooded soils by the Louisiana station have shown that the addition of organic residues increased slightly the amount of N lost by volatilization (denitrification). Flooding, as in rice culture, caused a loss of 78 parts per million or 8 percent of the N present. Where clover residue was added prior to flooding, the loss was 12 percent, and where rice straw was added, it was 10 percent. It was apparent that the nitrate-reducing capacity of the soil was increased by both flooding and organic matter. No loss of N was evident when the soil was held at optimum moisture. The numbers of aerobic N-fixing bacteria were increased by the organic matter but were reduced by flooding, whereas the anaerobic N-fixers increased in numbers with both flooding and the addition of organic matter.

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Oat straw and alfalfa hay, decomposed under different conditions in the presence of added inorganic N in studies at the Iowa station, gave no loss of N by denitrification under acid conditions, but resulted in a loss under alkaline conditions. This effect was found to be due to nitrite toxicity rather than to acidity alone. Because fungi are more tolerant to both nitrites and acidity than are bacteria, they predominated under the acid conditions to the extent that there was not sufficient bacterial activity to cause denitrification. Buffering decomposing plant material to an acid reaction eliminated such N losses as occurred under alkaline conditions.

Research at the New York (Cornell) station, using nitrate labeled with N^{15} isotope, showed that nitrate can be lost from soils through denitrification under fully aerobic conditions, even in the absence of added energy material, such as crop residues. The nitrate N that disappeared, under either aerobic or anaerobic conditions, was assimilated by micro-organisms or was lost from the soil as N_2 gas. The higher the amount of oxygen present, the less was the loss of N by denitrification. Regardless of the concentration of oxygen present, only a small quantity of the added nitrate was reduced to the ammonium form. This research also established that ammonium N is not converted to N_2 gas directly by micro-organisms. The results indicate that added nitrate N may be lost to an appreciable extent on poorly drained soils, and that ammonium N is therefore a more efficient source of N under conditions of moderate to poor soil aeration.

Nitrification

The Iowa station found that the concentration of oxygen required to insure the biological process of nitrification at optimum speed was about the same as that in ordinary air. Some nitrification occurred at oxygen concentrations slightly less than 0.4 percent. Approximately half as much nitrate was produced when oxygen was maintained at 2.1 percent as at 20 percent, although at 11 percent the rate of nitrification was almost as great as at 20 percent. The nitrification rate also varied with the amount of soil moisture present, being optimum when the soil pores were well filled with water providing there was ample space for air. In addition, the rate of nitrification was found to be lower in soils of pH 6.5 to 7.0 than in those above pH 7.1, and soils low in available phosphorus or potassium had lower nitrification rates than those high in these elements. A more rapid method was developed for determining the rate of nitrification of soils. Results by this method correlated well with crop response to applications of nitrogen.

Nitrogen Fixation

Experiments carried on at the Illinois station showed that, contrary to former beliefs, additions of large amounts of carbonaceous materials did not increase the number of Azotobacter (N-fixing bacteria) even at a relatively high soil pH. Additions of N fertilizers had little effect on the number of Azotobacter in the topsoil, but greatly increased the number in the subsoil. Azotobacter grew well in all soils when sucrose was added as the source of energy, but only in certain

of the soils studied when mannitol was the energy source. The low amount of available molybdenum may account for this failure in certain soils.

The Idaho station demonstrated that the N-fixing bacterium *Azotobacter chroococcum* produced more colored pigment (melanin) when certain amino acids were included in the growth medium. When 0.01 percent boron was added to the substrate in the presence of these amino acids (tyrosine, β-alanine, and glycine), still more melanin was produced. The amino acids cysteine and cystine were found to inhibit melanin production. Copper was also inhibitory to production of this pigment, as well as to growth of the organism. The basic metabolic rate of the organism as measured by oxygen consumption was reduced by boron concentrations above 0.01 percent, but was not influenced by lesser amounts of boron.

Adsorption of Nutrients by Bacteria

In attempting to find out how bacteria obtain mineral nutrients from the soil, scientists at the Kansas station have shown that there is no correlation between the electrical charge of bacterial cells and their capacity to adsorb positively charged nutrient ions (cations). Studies with enzyme-treated cells of different bacteria indicate that adsorption takes place at the cytoplasmic surface underneath the cell wall, and that it is probably not governed, therefore, by the surface electrical charge carried by each cell. A constant-rate, continuous-growth machine was developed that will greatly facilitate the study of surface phenomena.

Streptomycin in the Soil

Studies at the New Jersey station have shown that much larger quantities of streptomycin are required to inhibit bacterial activity in the soil than in solution substrates, and that the antibiotic is produced in soils only under exceptional conditions. Most organic materials that supported production of streptomycin by the streptomycin-producing organism in culture substrates failed to produce the antibiotic in the soil. The streptomycin is absorbed by higher plants from culture solutions, persists in plants for some time, and is recoverable in the sap. The antibiotic is decomposed so readily by microorganisms in the soil that there is much doubt whether soil applications can ever be relied upon for control of plant pathogenic organisms.

REDUCING LOSSES FROM PLANT DISEASES

The experiment stations are continuing to make material contributions toward the solution of some of the baffling problems of plant diseases. The research is directed (1) toward specific and immediate problems affecting crop production, and (2) toward general development of basic knowledge about plant diseases that is necessary to help cope with new disease situations.

Recent progress in the making of scientific instruments and equipment have been a boon to the plant pathologists. Development of

the electron microscope and its wider use at the State experiment stations has done much to facilitate research in the plant viruses. The use of radioactive isotopes has stimulated more penetrating study of cell behavior and other phenomena of plant growth related to disease. A new line of research receiving considerable emphasis is the development of systemic fungicides or chemotherapeutants. Although research with these compounds is encouraging, it is too early for many stations to report conclusive results. The significance and highly scientific nature of plant disease research, and its contribution to agricultural production, is reflected in the several examples of numerous station accomplishments reported in the past year.

Plant Viruses

Some viruses have a wide host range. These hosts include many of our economically important plants. Viruses are transmitted from plant to plant by insects and in many other ways. It is, therefore, important to know about the life history of the viruses and to understand how they may be spread, in order to adopt necessary control measures when the plants and crops get sick.

The California station has isolated seven viruses believed to be separate and distinct. They were taken from plants in the cucumber family growing in the State. The mosaic viruses are the aphid-borne cucumber, cantaloup, and western watermelon; the beetle-transmitted squash, muskmelon, and wild cucumber viruses; and the virus causing muskmelon vein necrosis, which has been transmitted by juice inoculation. The insect vectors for the latter have not yet been determined.

Antibiotic Studies

The organisms that cause certain diseases are becoming adjusted to antibiotics such as penicillin, streptomycin, and others; that is, they can tolerate heavier dosages of these materials. The reason for this change has not been completely understood. The Wisconsin station found that bacterial cultures which had never been exposed to antibiotics contained a small number of resistant cells. After treatment with antibiotics, these cells became more numerous because the susceptible cells had been killed. Eventually, these resistant cells dominated the culture and the disease caused by these organisms resisted treatment by antibiotics.

The New Jersey station investigated several new antibiotic-producing cultures in detail. One was found to produce an active antifungal agent which, although similar in most respects to fungicidin, has a marked activity against *Coccidioides*. Another culture was found to produce antibacterial and antifungal agents that were found to be identical with terramycin and rimocidin. A new antifungal agent was isolated that was particularly effective against *Candida albicans*, a yeast-like fungus that may cause serious lesions on many parts of the human body. This antibiotic was recently designated as candicidin. Further studies were carried out on the nutrition of *Streptomyces fradiae* and on the mechanism of formation of neomycin by this organism. A number of cultures were isolated that presented a marked action against the tuberculosis organism.

Nematodes Damage Many Crops

During the past few years the stations have recognized that nematodes or eelworms are causing injury to some of our more important food plants to a greater extent than was thought possible a few years ago. Today approximately 20 stations conduct research on various phases of the nematode problem.

Nematodes have often been blamed for plant injury when no other cause was evident or when they were associated with plant tissues in large numbers. Since the propagation of nematodes in sufficient quantity for research purposes is sometimes difficult, proof of their pathogenicity has often been neglected. By varying the number of nematodes (*Paratylenchus hamatus*) associated with celery roots, the Connecticut Agricultural Experiment Station found that the amount of injury and stunting of the celery plants was in direct proportion to the number of nematodes present. Previously this same nematode had been reported only on figs in California. Tests with methyl bromide-treated soil showed that plants growing in such soil weighed four times as much as those growing in nontreated soil. The Oklahoma station found in trials with muskmelons that row applications of soil fumigants for nematode control gave yield increases of 25 percent, which was practically equal to those obtained by treating entire soil areas. Only one-third as much ethylene dibromide was needed when applied in the row as when applied by area.

A survey of peanut fields by the North Carolina station showed that 70 percent were infested with the peanut root knot nematode in spite of the fact that a 2-year rotation was used on many of the farms. There was very little difference between the action of common nematicide materials applied in the row in reducing nematode damage.

On tobacco, a cyst-forming nematode was found by the Connecticut Agricultural Experiment Station that was morphologically indistinguishable from the golden nematode that attacks the potato. The tobacco cyst nematode can also attack tomato plants, though more weakly. It does not attack potatoes, however, nor does the golden nematode attack tobacco.

Field Crops

Cereal rusts

Determinations made by the Minnesota station showed that the virulent race 15B of stem rust which caused losses of over 10 million bushels of durum wheat in North Dakota and Minnesota during 1950 was found to be widespread in 1951. Partly because of drought in much of the area where the summer spores often overwinter and partly because of below-average temperature in the spring wheat area, stem rust did not develop rapidly in 1951, and consequently, it did relatively little damage. In 1951, race 15B, however, was found from Texas and Mississippi northward to Wisconsin, Minnesota, and North Dakota, and from Virginia and Pennsylvania westward to Colorado, Wyoming, and Montana. Of the 27 stem rust races identified by the Minnesota station from 686 collections, comprising 950 isolates, race 15B made up 21 percent of the total. It was exceeded in prevalence by only one other race, namely 56. Also, 41 isolates of stem rust were made from

the barberry by the Minnesota station. These comprised 18 races but 15B was isolated most frequently, emphasizing again the need for eradicating the rust-susceptible barberries as quickly as possible. Preliminary reports obtained on the development of stem rust in 1952 indicate that race 15B is causing serious reduction in yield of spring wheat in certain areas.

In greenhouse tests the Kansas station (coop. USDA) found excellent resistance in wheats to many races of leaf and stem rusts, including 15B. The principal sources of this combined resistance were Chinese [2] × *Agropyron elongatum*, Egypt Na. 101 × Cheyenne, Timstein × Pawnee [2], Bobin-Gaza-Bobin × Pawnee, the Brazilian variety Frontana, the Mexican variety Kentana, several selections from Kenya Colony, Red Egyptian, and many selections from complex wheat × *Agropyron* crosses.

Control of the cereal rusts depends on the constant development of new varieties that are resistant to the changing races of the parasites. One of the problems that has hampered the cereal breeder and pathologist in this work has been the preservation of the parasite. It can grow only on the living host plant and formerly could be stored for only short periods in the laboratory. This made it difficult to maintain collections of the many races of the rust organisms and to compare results among the investigators cooperating in rust research. Within the last 2 years, a new method, called lyophilization, has been successfully applied to rust by the Iowa station (coop. USDA) on this problem. Collections of *Puccinia coronata*, the oat crown rust parasite, have now been in storage up to 22 months with no significant loss of viability or change in pathogenicity. Similar results also have been obtained with the oat stem rust fungus, *P. graminis avenae*, and it appears that the method is applicable to any of the cereal rusts and perhaps to other obligate phytopathogenic fungi. The technique itself is simple and requires only ordinary laboratory apparatus.

Verticillium wilt of cotton

The Arizona station continued investigations on the verticillium wilt of cotton and found that the causal fungus can pass from the branches and pedicels into the bolls. The lint in immature bolls was a reasonably good medium for growth of the fungus, which also grew in the lumina and walls of the fibers. Experimental work by the New Mexico station (coop. USDA) indicated that several cultural practices may help to control this disease. These include a 1-year rotation with legumes or a small grain planting in high beds, and thick spacing of plants. A 15- to 20-percent increase in yield of seed cotton per acre was obtained following the legumes and a 37-percent increase occurred following barley. There was 30 percent less disease and yield was 16 percent higher, on the average, in the thick planting than in thin planting. Extra-high—approximately 15 inches—double-row beds resulted in decreased wilt percentages and increased yields. This is due in part to an increase in soil temperature of from 4° to 5° F. in the high beds over that in the conventional double-row beds.

In the greenhouse it was found that disease was most pronounced at a constant soil temperature of 78° F. As the soil temperature was increased, the severity of damage was reduced sharply and at a constant soil temperature of 90° almost no damage occurred to the cotton

plants. However, at soil temperatures below 78° the severity of wilt was pronounced over a considerable range, indicating that the wilt fungus was most damaging in its action at the cooler soil temperatures.

Verticillium wilt of potato

The prevalence of *Verticillium* in Connecticut potatoes which showed stem end discoloration was definitely shown by isolating the organism and inoculating it into seed potatoes. According to the Connecticut Agricultural Experiment Station, there was considerable wilt in potato fields in 1951, much of which was due to *Verticillium*. When isolates were compared with *Verticillium* recovered from Maine-grown potatoes, they were distinctly different, suggesting that the Connecticut *Verticillium* is not carried by Maine seed potatoes but comes from races of *Verticillium* living in Connecticut soils. As a practical result, Connecticut growers are being advised to practice crop rotation and to use nonsusceptible host plants.

The Idaho station found that potato varieties reacted differently to verticillium wilt, a disease that has recently become prevalent in certain potato-growing areas. Yields ranging from 554 sacks per acre were obtained for a resistant variety, as compared with 174 sacks for a susceptible variety. The most resistant varieties were Katahdin and Seedling 41956 and their relatives, and selections of Jubel and other foreign varieties.

Concentrate sprays effective

The use of concentrate fungicide sprays for the control of various diseases is receiving a great deal of attention from numerous experiment station workers. Just how concentrated a spray can be and still be effective has not been determined satisfactorily. If concentrate sprays prove to be efficient, they will do much to reduce the cost of applications. Experiments by the New York (Cornell) station are helping to shed light on this problem. Applications of 2X or double the usual strength of bordeaux mixture, Dithane D–14 plus zinc sulfate, and Crag 658 at the rate of 50 to 60 gallons per acre, controlled late blight and gave as high yields of potatoes as did the 1X concentration of these fungicides in 100 to 200 gallons of water per acre. However, unsatisfactory control of late blight was obtained with a 4X concentration.

Sweetpotato diseases

Research at the Maryland station has shown that the reason why the pox disease of sweetpotato cannot always be controlled by treating the soil with sulfur is that the fungus has an acid-tolerant strain that does not react to the usual sulfur treatment. It was also found that the cracking of sweetpotato roots may be due in part to the prevalence of pox.

The Virginia station obtained evidence that cracking of sweetpotatoes is associated with nematodes. Treating the soil with a nematicide reduced this cracking from 51 percent in the nontreated to 15 percent in the treated plot. A sprout decay of sweetpotatoes, of unknown cause, which destroyed from 20 to 25 percent of the sprouts, was eliminated by the addition of superphosphate, according to reports by the New Jersey station.

Tobacco diseases

The Maryland station (coop. USDA) found that the tobacco mosaic virus is widely distributed throughout the tobacco-producing areas of the State and that it may be carried back to the land by the application of unsterilized stems and waste leaf scraps as a fertilizer or soil conditioner. Tests indicate, however, that the virus in tobacco stems can be inactivated by exposure for 15 minutes or longer to a temperature of 212° F. in a saturated atmosphere.

By fall plowing or by leaving the land out of tobacco for a year or more, the Connecticut station drastically reduced tobacco mosaic. This indicates that cultural methods can do much to control some of the more serious diseases of tobacco. The use of soil fumigants in areas heavily infested with nematodes added from $75 to $140 per acre to the value of tobacco, according to the North Carolina station.

Fruit Diseases

Fire blight may lose its burn

The Colorado, Missouri, and Arkansas stations report that fire blight, one of the most troublesome diseases of apples and pears, may lose some of its potency. The Colorado station found that spraying Dithane Z–78 in the 10-percent bloom and again in full bloom reduced the incidence of current season blossom and twig infection approximately 75 percent. This spray method, together with sanitary pruning and treatment of hold-over cankers, has become standard practice in fire blight control in Colorado.

Infections were markedly reduced on apple trees in full bloom sprayed with streptomycin or thiolutin, according to a Missouri report. Calcium hypochlorite, a very commonly used laboratory disinfectant, was found by the Arkansas station to be equally as effective in controlling fire blight as bordeaux mixture, and it did not russet the fruit.

A technique for maintaining virulent cultures of the fire blight organism was found by the Illinois station which should facilitate further studies of the disease. It was observed that the fire blight bacterium was able to survive over winter in mummied pear fruit. By inoculating pears with pure cultures of the organism and placing them in a refrigerator maintained at 5° C., a virulent culture of the fire blight bacterium could be isolated for tree inoculations in the spring.

Vegetable Diseases

Better control of row crop foliar diseases

Many vegetable growers are still waiting for more efficient concentrate spraying methods to be developed for the control of foliar diseases in row vegetable crops. The Ohio station has carried on research designed to determine additional details on the technique of spray application under practical field conditions. It was found that 2X and 4X spray concentrations applied at 40 and 80 gallons gave approximately as good control of foliar diseases of tomatoes as did a 1X concentration at 160 gallons per acre.

Tomato-disease control

In 1947, after several years' tests by the New York State station, a split schedule of ziram and copper, applied in the order of ziram, ziram, copper, ziram, copper, proved to be the most effective spray schedule for the control of the three major tomato diseases in western New York—early blight, late blight, and anthracnose. Only during the last 2 years has any single fungicide or combination of fungicides proved superior to this schedule insofar as disease control and yield were concerned when applied in a five-application schedule. Recently "Manzate" and Orthocide 406, two new materials, have given control of early blight and anthracnose equal to that of the split schedule, and in addition, have resulted in better yields. Indications are that application of these two spray materials will give even better results than the ziram-copper schedule.

Experiments conducted during the past 2 years show that it is the amount of actual fungicide used per acre that determines the disease control, and not necessarily the amount of water per acre that is used in applying these materials. For instance, 4 pounds of a fungicide such as Manzate applied in 100 gallons of water per acre has given as good control of early blight and anthracnose as the same amount of fungicide applied in 200 gallons of water per acre.

The Indiana station reports that approximately $25 per acre spent for spraying to control diseases of tomatoes resulted in the production of an additional 5½ tons of fruit per acre. Tomatoes sprayed five times yielded from 11.9 to 12.6 tons per acre, varying somewhat with the kind of spray used.

Lettuce diseases controlled

The cause of a leafspot disease plaguing coastal California lettuce growers for more than 20 years is no longer a mystery. It was recently found that a *Stemphylium* fungus makes the brown, scorched spots on leaf-type lettuce. Turning under these diseased leaves before planting a new crop reduced the spread of the disease. The Arizona station found that preplanting surface applications to the soil of "Aero" calcium cyanamide (20.6 percent nitrogen) at the rate of 1,000 pounds per acre, effectively controlled lettuce drop.

Diseases of Ornamentals

Gladiolus plantings, the Wisconsin station found, are potential reservoirs of bean virus 2, tobacco ringspot virus, and cucumber virus 1. This was the first record of gladiolus as a host of tobacco ringspot virus.

The Colorado station recently obtained strong evidence that the carnation mosaic virus may be transmitted from plant to plant through root grafts. Repeated tests in insect-proof cages gave added evidence that the carnation mosaic virus may be transmitted through roots. There is no evidence that the virus was carried from infected plants by the soil solution. Further work by the Colorado station indicates that ultra-violet light may prove to be a rapid means of diagnosing carnation mosaic. Extracts of mosaic-infected plants fluoresce a light pink at the interface between the water and the butanol. Solutions from virus-free plants have no similar fluorescence.

The Mississippi station was able to control damping-off in China-asters by steam pasteurization of the medium at 100° F. for 1 hour and by treatment with Dowfume MC–2 at 1 pound per 12½ cubic feet. It also developed an improved method of inoculating China-asters with the aster wilt organism, which will enable growers as well as researchers to test quickly and accurately the susceptibility of any variety to aster wilt.

Tree Diseases

The Illinois station estimates that 65 percent of the 10 billion feet of merchantable timber in the State is oak. More than 100,000 board feet of merchantable timber have been killed by the oak wilt disease. In the summer of 1951, trees containing 50,000 board feet of timber showed the disease for the first time. Observations show that trees in the red oak group get the disease more rapidly than white oaks; that the disease kills red oaks much more rapidly than white oaks; that within a species the largest and most valuable trees are most likely to be attacked; and that the damage is not localized but is distributed quite uniformly over the 1,600-acre area and in adjacent woodlands.

This potentially serious disease is receiving attention by many of the State stations. Laboratory investigations by the West Virginia station have shown that quick identification of the oak wilt fungus may be made in liquid media or on a special agar medium low in sugar and containing phenylalanine as the only nitrogen source. Early diagnosis of the causal fungus by this method should help to prevent the disease from spreading.

The rates of movement of liquid in the vessels of healthy and diseased northern pin oak were determined by the Wisconsin station with solutions of radioactive rubidium. This chemical moved upward approximately 1 foot per minute in healthy trees, as well as in inoculated trees, prior to symptom development. However, movement was reduced abruptly by 90 percent and 99 percent at the time of incipient and severe wilt, respectively. These results indicate that vessel plugging results when the host is infected and that such obstruction may limit the available water supply, causing a shortage which may help to bring on leaf symptoms.

During the past year, the Missouri station (coop. USDA) found that tanoak, bush chinquapin, European chestnut, and two Asiatic oak species were susceptible to the oak wilt fungus in greenhouse inoculation tests. The progression of symptom development appeared to be similar in all species. A great many chemicals have been tried by the Iowa station in an attempt to control oak wilt. Some of the chemicals retarded the disease sufficiently to warrant further investigations. The mode of action of these chemicals in controlling this fungus suggests that they are able to neutralize the toxin produced by the fungus.

RESEARCH ON USEFUL AND DESTRUCTIVE INSECTS

Recent reports have emphasized the significance of using modern methods for insect control. The introduction of the newer insecticides and acaricides (mite-killing chemicals) represents a definite step ahead in scientific farming. Many of these insect controls grew out

of principles first established in fundamental research at the agricultural experiment stations, and out of close collaboration between station entomologists and scientists of the chemical industries. Combined with the new equipment and methods of mechanized crop production, chemical insect control methods have become striking examples of advances currently being made in farm technology.

Studies on the nature of useful insects have been continued. These have led to improved practices under which some insects are used to control other insects or mites. For example, insects known as dusty wings are encouraged to feed on mites that attack citrus orchards. New facts are also coming to light with regard to the use of honey bees as pollinizers for grassland legumes. Examples of results from such research are here presented.

Honey Bees Increase Grassland Legume Seed Yields

Research on honey bees and legumes at a number of the State experiment stations points to a need for increasing honey bee populations in fields of legumes during bloom to insure good pollination for seed production. Bees were found to be essential for good seed crops of several legumes in studies made by the Oregon station. Crimson clover to which bees had access produced 6,917 seeds from 100 heads compared with 508 seeds from 100 heads when bees were excluded—more than 13 times as many. Hairy vetch with bees made 390 seeds and without bees 118 seeds from an equal number of pods. No seed was produced by red clover and birdsfoot trefoil unless bees were available for pollination.

The Iowa station determined the relation of distance from beehives to pollination of red clover by honey bees. During two seasons the number of seed set declined as distance from the hives increased. Seed yield in the clover field maintained a relatively high level as far as 500 feet away in one year and as far as 350 feet away the next year. At these distances pollination dropped to a definitely lower level, and from there on declined gradually. The results indicate that under Iowa conditions hives of bees should be placed throughout clover fields in groups 600 to 900 feet apart, and half that far from the edge of the field, for maximum pollination and seed set.

In its research on the pollination of sweetclover the Texas station obtained an average yield of 130 pounds of seed per acre in cages from which bees were excluded in an experimental field of second-year Madrid sweetclover. Sweetclover varieties apparently are self-fertile to a certain extent. Adjoining cages in which bees were enclosed averaged nearly double this amount, although bees confined in cages do not work in a normal manner. Adjacent open plats, with approximately two-thirds of a hive of bees per acre, averaged three times the seed yield obtained from cages without bees. An experimental field of second-year Evergeen sweetclover yielded 33 pounds of seed per acre in cages from which bees were excluded. Adjoining cages provided with bees averaged 2.5 times this amount. Open field plats, with slightly less than one hive of bees per acre, averaged 3.5 times the yield of the check plats.

Research on the pollination of Ladino clover by the South Carolina station revealed that in screened cages from which pollinating insects

were excluded only 3 seeds per 50 heads were formed. When the blossoms were in a cage with honey bees 90 seeds per 50 heads were set. Open-pollinated Ladino blossoms—produced outside of a cage—yielded 73 seeds per 50 heads. The pollinizers visiting the open-pollinated blossoms consisted of approximately 10 honey bees to one other kind of bee. The other bees visiting the Ladino clover blossoms were mainly small bumblebees. A few were small solitary bees.

An experiment was conducted by the Alabama station to determine the value of honey bees in the pollination of crimson clover. Honey bees were placed in or near the clover fields at rates of ⅔, 2, and 5⅓ colonies per acre. Screened cages were used to exclude the bees from small areas. Clover exposed to bees yielded 384 to 535 more pounds of clean seed per acre than clover from which bees were excluded.

The Oklahoma station found that in 1 year two hives of honey bees per acre increased vetch seed yields 2.3 times as compared to areas from which bees were excluded by screens. The increase of 304 pounds per acre was worth around $50 to the grower and also provided an increased seed supply needed for the grasslands program.

Mite-killing Chemicals and Insects Work Together

The California station has developed a method under which the new acaricides can be used in combination with the predatory dusty wings to control mites in citrus groves. The dusty wings are delicate, whitish insects barely one-eighth inch long. Both larval and adult stages destroy mites. The larvae, with piercing mouth parts, suck the body juices from their prey. The adults consume whole individuals of the prey, legs and all. But dusty wings must also have a source of plant nectar or of honeydew, the fluid secreted by insects such as scales, mealybugs, or aphids. For this reason dusty wings do not thrive in groves treated with insecticides which destroy the honeydew-secreting insects. Careful choice of insecticides is, therefore, necessary if the dusty wings are to serve as mite killers.

Field experiments of the California station have shown that when the new acaricides are used on citrus trees, exisiting dusty wings live on the low populations of mites and insects that remain alive in the grove despite chemical treatment. The predaceous activity of the dusty wings is thus maintained and serves to prolong the period of effective mite control brought about by the acaricide. However, dusty wings themselves are extremely sensitive to insecticides, a factor in the increase of citrus mites following the use of DDT.

Insect Carriers of Two Plant Diseases Identified

The California station has discovered that the melon aphid is a carrier of the citrus quick-decline disease. This virus disease was first noted in California in 1939 and has been spreading. It is particularly destructive to trees of sweet orange growing on sour orange rootstocks. Although under experimental conditions the melon aphid is a rather ineffective carrier of the disease, studies of dispersal flights have indicated that enough individuals fly in a citrus orchard to account for the observed spread of the disease. Surveys have shown high populations of melon aphid breeding on citrus in certain areas

in southern California in which the quick-decline disease has spread rapidly, and generally low populations in areas in which the disease has spread slowly.

None of the other 311 species of insects tested has transmitted the disease, with the possible exception of certain treehoppers, about which the evidence is inconclusive. The California station also determined that the germinate leafhopper is a carrier of the virus of yellow leaf roll of peaches. These discoveries answer two of the most puzzling questions growers and research people heretofore have faced, namely, how are the quick-decline and the yellow leaf roll viruses spread.

Rootworms Controlled in Peanuts

The Virginia station (coop. USDA) has found aldrin and toxaphene effective against the southern corn rootworm attacking peanuts. However, the two insecticides proved effective only in the darker and heavier peanut soils, and gave "no significant monetary return" in light sandy soils. In the heavy soils, more peanuts were produced where the insecticides were used and the grade of the entire crop was improved as compared with peanuts on the test plots on which no insecticides were used. This means that the insecticides will be beneficial on 25 to 30 percent of Virginia's peanut land—at least 30,000 acres. Yields can be expected to increase from 200 to 700 pounds per acre, and the grade may be raised to yield from 1 to 3 cents more a pound.

Either insecticide may be applied with fertilizer-spreading equipment or with dusters. The estimated cost of either insecticide was less than $10 an acre. Treated land yielded from $5 an acre more in the case of light sandy soil, to $106 per acre more in the heaviest soil. Use of the insecticides is expected to boost Virginia income from peanuts by $1,500,000 a year.

Corn Rootworm Control Increased Yield

An infestation of southern corn rootworm that had damaged about two-thirds of the young corn in a 4-acre field was studied in an experiment by the Kentucky station. The corn was replanted over the original rows and treated with BHC (benzene hexachloride) at the rate of 2 pounds of gamma isomer per acre, toxaphene at 3 pounds per acre, and chlordane, aldrin, and dieldrin at 5 pounds per acre, applied as 13 gallons of spray mixture to the soil surface. When the corn was cut for silage the plots treated with BHC gave the highest yield, 21,697 pounds of silage per acre; yields produced by the other insecticides ranged from 19,780 to 19,015 pounds per acre. The untreated check plots averaged 14,915 pounds per acre. A comparison of these figures shows that the aldrin, chlordane, dieldrin, and toxaphene treatments resulted in increased yields of silage exceeding 2 tons and BHC in an increase exceeding 3 tons per acre.

In another field in Kentucky the same treatments were applied by the Kentucky station, except that the chlordane, aldrin, and dieldrin were applied at the rate of 4 instead of 5 pounds per acre. The spray mixtures were applied with a tractor-mounted, weed-type spray boom at 30 pounds pressure, 6 gallons of spray per acre being applied in

a band over the row 3 days after planting. Although the infestation was relatively light, the yields of all the treated plots except one were significantly greater than the yield of the untreated check plot, 60.1 bushels per acre. The aldrin plots produced he highest average yield, 76.5 bushels per acre, or an increase of 16.4 bushels of corn per acre.

The Texas station found that southern corn rootworm damage occurs more often in corn following winter legumes than on land that has been fallowed during the winter. The damage to seedling corn results from the larvae eating into the seedling, often destroying the center shoot and killing the plant. In some years stands of corn have been completely lost because of this pest. Through an application of chlordane or BHC the Texas station obtained yields of 77.4 and 73.2 bushels of shelled corn per acre, respectively, as compared with 52.2 bushels from untreated corn. In other experiments effective control of the southern corn rootworm was obtained with six insecticides applied as dusts to the furrow immediately before planting.

Alfalfa Weevil Control With Dieldrin

Many farmers and ranchers, forced out of alfalfa growing because of the spread of the alfalfa weevil may now raise this crop as the result of weevil research carried on by the Montana station. The weevil was first introduced from Europe about 50 years ago. It spread rapidly, first through the Salt Lake Valley, then to other Western States, and later to some Eastern Seaboard States. Weevil-damaged alfalfa hay is unpalatable, has markedly less carotene, and under customary handling is far less leafy than normally grown alfalfa. To offset this damage, which causes heavy losses each year, the Montana station undertook studies of the weevil's life cycle and habits. The research showed that the most likely point in the weevil's life cycle at which practical control might be obtained at reasonable cost is when adult weevils come out of hibernation and before they lay their eggs. Dieldrin applied at this time at the rate of 4 ounces per acre proved so successful in gaining control of the weevil that this treatment has been generally accepted. It is now used throughout the entire weevil-infested area. The cost of treatment was slightly more than $1 an acre. Recent trials where weevils are numerous have shown that on the first cutting alone a 0.2- to 0.7-ton increase in alfalfa per acre may be expected from this treatment.

Horn Fly Control Profitable

Horn flies attacking cattle can be economically controlled under South Dakota conditions by a properly located cable-type self-applicator developed by the State experiment station. An 18-foot section of burlap-covered cable was loosely suspended between two solidly placed wooden fence posts about 16 feet apart. The burlap was soaked with a 5-percent oil solution of insecticide poured from a pitcher. The insecticide was rubbed off the burlap onto the backs of the cattle as they walked under the cable. DDT was the most effective material used. Fresh insecticide was added every two to three weeks. No significant skin irritation was seen on the animals using this applicator. This method was at least as effective in horn fly control

as standard spraying techniques, resulted in large savings in time and labor, and did not disturb the cattle.

More than 200 tests of self-applicators made at the Oklahoma station indicate that cattle may be kept relatively free from horn flies for 1 cent per head per season. Success of these self-applicators was almost completely dependent upon proper placement. In pastures with little or no large brush preferred places were near water tanks, mineral or "cake" feeding locations, or shade. In brushy pastures, close observation of the animals to determine where they loafed most was needed so that the self-applicator could be placed to the best advantage.

In spraying experiments conducted by the Oklahoma station (coop. USDA) at Fort Supply, treated cattle were sprayed with 2 quarts of 0.5 DDT on the last day of May, June, July, and August for horn fly control. Check animals were not sprayed. Over a period of 7 years, these carefully controlled experiments have shown that an increase in weight of about 18 pounds per animal per fly season was obtained from good horn fly control. The lowest increase obtained during the 7-year study was 12 pounds per year, whereas the highest gain was 28 pounds per animal per year.

Insecticides Control Pickleworm

Insecticide dusts applied to squash, cantaloup, and cucumbers in experimental plots at the Georgia station increased the yields a maximum of 3,314, 5,940, and 6,177 pounds of worm-free fruit per acre, respectively. The pickleworm infestation was moderate to heavy during this test and the weather was dry so that the insecticides were not washed off by frequent rains. The squash and cucumber plots were dusted 6 times each and the cantaloup plots 7 times. Parathion, lindane, and an insecticide known under the trade name of EPN (O-ethyl O-*p*-nitrophenyl benzenethiophosphonate) and DDT gave increased yields of worm-free squash and cucumbers 2 to 3 times greater and of cantaloups 3½ to 5 times greater than the untreated plots.

DDT Dust Increases Yield of Fall Field Peas

The Louisiana station has tested the effectiveness of DDT dust in controlling the cowpea curculio and stink bugs. These insects are largely responsible for late summer and fall failures of field peas in Louisiana. When the pods were approximately one-fourth mature, 10 percent DDT dust was applied to the trial plots. One-half of the plots received a second application 1 week later. Plots dusted once produced 1,938 pounds of clean green pods per acre. Those receiving two applications produced 2,283 pounds per acre, and the untreated plots produced 1,560 pounds. Plots treated once showed a 24-percent increase in yield of peas over the untreated plots; those getting two applications of DDT gave a 46-percent yield increase.

Insect Control Reduces Cabbage Bursting

The amount of bursting of cabbage heads was reduced about 50 percent by insect control in research carried on at the New York

State Station and yields were increased 3 to 5½ tons per acre. Fertilizing the cabbage increased yields substantially, but when no insecticides were used the fertilization increased the bursting of the heads. The beneficial effects of the insecticides were evident regardless of the amount of fertilizer used. This effect of the insecticides is believed to be brought about by maintaining uninjured and complete leaf areas. Not only were the leaves stronger and more resistant to physical stresses that cause bursting, but they also had a greater transpiring surface which kept internal moisture fluctuations to a minimum.

Border Spraying Controls Melon Flies

At the Hawaii station spraying border vegetation adjacent to, but outside of, crop areas with DDT was found to be an effective control for the melon fly, which is a severe pest of such crops as tomatoes, cucumber, and melons in the Hawaiian Islands. Border spraying was developed after a detailed study of the habits of the flies in and around infested fields had revealed that practically all flies found on tomato plants were females ready to lay eggs. Males, immature females, and gravid (egg-laying) females are commonly found in large numbers on certain plants such as corn or natural growth of plants like Crotolaria, pigeonpea, and cocklebur in the vicinity of crop areas. Flies are rarely present in the field before sunrise. As the day gets brighter and warmer, they become active, and the gravid females, which have spent the night in vegetation near the field, fly into the field to lay egs. After laying their eggs, the flies return to the vegetation near the field. Here they feed on plant exudations, honeydew secretions of aphids and other insects, and on pollen and nectar of flowers.

After discovering the habits of the flies, a mist blower was used to apply a 5-percent DDT-oil emulsion directly to the flies in the vegetation bordering crop areas. Tomato samples taken within a 3-acre field thus treated had an average infestation of 2.7 percent as compared with 64.7 percent in an untreated field. Some other insecticides are also effective as border sprays.

Pea Aphid Control

The Maryland experiment station has developed a practical control measure for pea aphids in the State. The station reports that use of DDT and parathion to control pea aphids, in accordance with station findings, has proved satisfactory and profitable to Maryland growers. From 20 to 80 percent of Maryland's 9,000- to 12,000-acre pea crop requires annual protection against the aphid. On the Eastern Shore it has been necessary to use control measures against this insect in 17 of the past 18 crop years. Cost of treatment varies from $2.50 to $7 per acre according to the method used. For the period 1936 to 1944, before DDT and parathion came into use, the average per acre production of peas was 1,588 pounds. From 1945 to 1951, after the use of DDT and parathion, the average production was 2,276 pounds per acre, which represents an average increase of 43 percent above the 1936–44 production.

VETERINARY RESEARCH

Veterinary research is concerned not merely with healing sick animals but with the prevention of disease and general improvement in the health and quality of animals. An important fact to be remembered in future research in this field is that it is more important to search out fundamental facts upon which practical control and preventive measures may later be based than to emphasize the service and diagnostic and survey phases, which undoubtedly contribute to the studies and often indicate problems for which additional information is needed. Service, diagnostic, and survey studies rightfully fall into the sphere of the practicing veterinarian or the State and Federal livestock sanitary officials who in the long run profit by results of the above-mentioned fundamental type of veterinary research.

A few examples that illustrate the progress of veterinary research at the experiment stations are presented here.

"X-Disease" (Hyperkeratosis of Cattle)

Last year it was reported that the study of X-disease "has been narrowed to two phases—one, investigations of the chemical nature of a toxic agent found to be a possible cause; two, study of an apparently infectious agent which in some respects causes a similar condition but which may or may not be a direct or associated cause of this disease."

During the year excellent progress was made in this well-coordinated study and as a result the infectious phase has been ruled out. Leaders of this study agree that cattle may become affected with X-disease by exposure to or by eating highly chlorinated naphthalenes contained in certain lubricants or by as yet unknown toxic ingredients in feedstuffs. The study is being continued in an effort to disclose other possible causes of X-disease as well as products that might contain toxic chemicals. Meanwhile, with a view to preventing or greatly reducing incidence of this condition in cattle, farmers have been advised to keep their cattle away from tractors, combines, and other farm machinery where it may be possible for them to contact or eat grease or oil. The farmers have been further advised that used crankcase oil, or oil drums and similar containers, should be kept away from cattle; and that drainage from around grease racks and in farm machinery sheds should not be allowed to contaminate lots or pastures to which cattle have accesss.

The disease was described in our 1948 report as a mysterious condition in cattle, and it was noted that formal research memoranda were being drawn up at that time by several of the State experiment stations and the Department, for the purpose of studying the disease.

The concerted efforts of the Department and the State experiment station researchers have resulted in lifting much of the mystery surrounding X-disease. The Department and the following 17 State experiment stations are responsible for the coordinated, continuing study of this problem: Alabama, Colorado, Storrs (Conn.), Georgia, Illinois, Indiana, Kansas, Michigan, Montana, Nebraska, New Jersey, New York (Cornell), North Dakota, Pennsylvania, Tennessee, Texas, and Virginia.

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Air-Sac Infection of Poultry

Approximately two or three years ago a chronic respiratory disease was encountered in poultry. Since it often involved birds under study for Newcastle disease and its relationship to that disease was unknown, the cooperative Newcastle research project was amended by the technical committees to include investigations of allied respiratory diseases which often make definite diagnosis and control difficult. This chronic respiratory disease or so-called air-sac infection has been spreading through poultry flocks of the Nation at an alarming rate. Producers along the eastern seaboard have been particularly hard hit with poultry deaths amounting to 30 to 50 percent. The disease causes marked inflammation of the air sacs, the membranes of which are generally thickened and covered with a frothy or cheesy coating. It also manifests itself in retarded growth and reduced egg production. The causative agent is thought by some to be responsible for sinusitis, a serious disease of turkeys.

Recognition of the disease stimulated rather widespread interest at a number of the experiment stations, and the following stations have been engaged in preliminary, fundamental investigations of one or more phases of this disease or complex in chickens or turkeys, or both: California, Storrs (Conn.), Delaware, Massachusetts, Minnesota, New Jersey, New York (Cornell), North Carolina, Rhode Island, Texas, Virginia, Washington, and West Virginia.

Because of the complexity and seriousness of the disease, the Department and a number of the State experiment stations have developed a cooperative study in much the same way that the Newcastle disease program was started in 1946.

Is this a disease in itself? Is it related to turkey sinusitis? What is its relationship to Newcastle and allied respiratory diseases? Is the causative agent a true virus and how is the disease spread? These are but a few of the questions to be answered. Progress of the study will be accounted for in future annual reports.

Newcastle Disease Research

Research on immunization and other control measures continues on a regional and interregional basis in an effort to control adequately and efficiently new "strains" of the virus as they appear. Studies are also in progress on ways to improve and standardize methods of diagnosing the disease. These studies are of particular importance since the over-all picture is cluttered with allied respiratory diseases that often masquerade as Newcastle disease and make its definite diagnosis difficult. Without proper diagnoses there is small chance of success for immunization or control measures. The following stations (coop. USDA) are studying these and other problems related to Newcastle disease: California, Storrs (Conn.), Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York (Cornell), North Dakota, Ohio, Rhode Island, South Dakota, Texas, Virginia, West Virginia, and Wisconsin.

The Rhode Island station reports the isolation of Newcastle disease virus from the lung of a 6-month-old naturally infected calf that had exhibited respiratory symptoms before death.

Meanwhile at the Maryland station, it was found that the cotton rat is susceptible by intracerebral inoculation to six different strains of Newcastle disease virus which may involve the central nervous system.

In our last annual report it was stated: "the Virginia station announces that vaccination by nebulization (spraying) with B_1 vaccine is practical and safe." During the past year this station has adapted this spray technique for use on day-old chicks in boxes of 100-chick capacity. The results have been very encouraging. It was possible to vaccinate 100 chicks every 3 minutes without extra handling. There was no undue reaction from vaccination and a satisfactory immunity was obtained. Use of this method will effect a great saving in the labor and time required for vaccination.

Infectious Keratoconjunctivitis (Pinkeye) of Cattle

Research at the Texas station has shown that the bacterium, *Hemophilus bovis*, is the causal agent of pinkeye in cattle. The organism when grown on artificial media dissociated into smooth and rough colonies, but only the former produced infection when introduced into the eyes of susceptible cattle. It was also found that a formaldehyde-killed bacterin containing the smooth type colony of *H. bovis* resulted in a solid immunity up to 6 months, whereas injections of a viable vaccine produced a still stronger immunity which resisted artificial challenge up to 12 months. A practical method for the preparation and suspension of the vaccine that involves the use of solid media for growth, a spray technique for inoculating the media, and a formula for obtaining an even suspension of the vaccines have been developed.

Immunization Against Hog Cholera

Preliminary studies at the Virginia station show that nitrogen mustard will attenuate the virus of hog cholera. This attenuated virus is highly antigenic and develops satisfactory immunity to pen and artificial exposure. The attenuated virus produces no ill effects in injected pigs, and such pigs are of no danger to noninjected, susceptible pigs. The treated virus can be used up to 24 hours after its preparation. These findings offer an additional means of preparing an immunizing agent against hog cholera, one that does not have the limitations of the serum-virus method. The studies are being continued in order to determine the duration of protection, and other factors which may affect use of this material.

Treatment of Ketosis in Dairy Cattle

Ketosis has been of increasing importance since it was recognized about 20 years ago. Cows affected with it lose their appetites, lose weight, and drop off in milk production. They may make a gradual recovery without treatment, but there is a loss of milk for several weeks.

The Maryland station, after 6 years of intensive study of ketosis, reports that cortisone is a cure for this condition. The station has observed that first symptoms of ketosis appear at about the ninth day after calving, at which time the blood sugar had fallen to a low level.

These investigators believe that true spontaneous ketosis in dairy cows is due to adrenal gland deficiency. This gland in turn is probably deficient because of improper functioning of the pituitary gland. The investigators have found that cortisone and ACTH are about equally good in correcting both these deficiencies and in bringing about an incidental increase of blood sugar and promoting recovery within a relatively short time, depending on the size of dose. This action, of course, applies to uncomplicated, spontaneous ketosis. Feeding sugar or molasses during the dry period did not effectively prevent ketosis, but it is thought that this treatment is helpful for the first few weeks following calving in those herds in which the incidence of ketosis is high.

Wisconsin dairy specialists may have found a low-cost cure for ketosis. They want to test the material further before they make any recommendations, but an inexpensive salt called sodium acetate looks very promising. This discovery arose from research on rumen digestion. The changes in the fatty acids of the rumen and the effect on milk production suggested that there is a possible relationship between these acids and ketosis, which results from an upset of the fatty acids of the blood stream. Since sodium acetate had been successful in correcting the low test caused by fatty acid upset in the rumen, the dairy specialists reasoned that it might also help to correct the fatty acid upset in the blood stream and thus cure the disease. Several cows with ketosis were fed ¼ to 1 pound of the salt and most of them have recovered from the disease. However, the dairy specialists are urging caution in the use of the chemical. It will not cure all cases of ketosis—especially if there are complicating conditions. The scientists are encouraging veterinarians to try sodium acetate and to report their results. If the treatment works, it could save millions of dollars each year in Wisconsin alone.

New York (Cornell) reports that sodium propionate, a white powder used as a mold inhibitor by bakers, has brought about recovery in cows suffering from this condition. Affected cows apparently use this substance to increase the amount of sugar in their blood. Tests indicated that one-half pound of sodium propionate per day for 10 days is sufficient for a cure and is relatively inexpensive.

Liver Fluke Infection in Cattle

It was previously reported that as a result of its Island-wide survey, the Puerto Rico station found that in 1 year more than 6.24 percent of cattle livers (total weight of diseased livers estimated at 45,871 pounds) were condemned because of liver fluke infestation. The station has continued its study and reports promising results from the use of an intradermal (skin) test for diagnosis of the infection in cattle. So far 94 percent of 87 such tests performed have conformed with the findings on physical examinations of livers from freshly slaughtered cattle. Use of the test may help in the maintenance of fluke-free herds and thus reduce to a minimum the losses due to liver infestation and the resultant, unfavorable influences on milk and meat production. The test will also indicate which animals should be treated and when to treat them.

Cattle Losses Due to Trichloroethylene-Extracted Soybean Feeds

The Kansas station reports that heavy losses were encountered in a herd of cattle fed a high level of trichloroethylene-extracted soybean pellets. Similar losses had been reported from the stations in Colorado, Iowa, Minnesota, and South Dakota. Feeding experiments conducted by the Kansas investigators have definitely proved that a hemorrhagenic factor is present in soybean feed extracted by this process. Cattle fed the soybean pellets developed internal hemorrhages throughout the whole body, which could not be controlled by medicinal treatment. As a result of the Kansas station findings, this extraction process is no longer used by mills in Kansas for production of soybean feed for ruminants.

Bacitracin Treatment for Shipping Fever

Bacitracin has been found by the Wyoming station to have a beneficial effect in the treatment of hemorrhagic septicemia (shipping fever) of sheep and cattle. Studies on this subject have included field trials in cooperation with practicing veterinarians and control studies on animals owned by the University. An intramuscular injection of 10,000 units of bacitracin was effective in treating cattle with uncomplicated hemorrhagic septicemia, although 20,000 units were necessary to treat the disease in sheep.

The foregoing are but a few examples of the studies in the field of veterinary research. Many others of equal importance are in progress, and as their findings are definitely established, the results will be made known through technical and popular publications.

RESEARCH IN LIVESTOCK PRODUCTION

Many of the State experiment stations are continuing to contribute materially to the bringing about of greater efficiency in livestock production. Emphasis is placed both on the improvement of existing breeds and on cross-breeding, as well as on new practices whereby meat can be produced with greater economy. The Nation-wide emphasis on grassland farming is in large measure an effort to bring about a sustained program of pasture and forage abundance, thus assuring the Nation of a continued supply of animal products at reasonable prices. Much of the station research is carried on in close association with the livestock industry and with the United States Department of Agriculture which is cooperating with the experiment stations in regional breeding and related projects. In recent years efficient utilization of forage and of supplementary feeds has been given special emphasis. Examples of outstanding contributions along the lines mentioned, as reported in the past year, are summarized briefly in subsequent pages.

Cattle

Cornstalks and cobs reduce cost of cattle gains

Through research on the nutrient requirements of rumen microorganisms, animal scientists are learning how to make more efficient

use of forage crops and low-grade roughages in feeding cattle and sheep. Results of a recent cattle-feeding experiment reported by the Iowa station indicate that cornstalks and cobs fed with either of two specially prepared supplements can reduce the cost of beef gains up to 20 percent and produce yields of from 55 to 70 percent more beef per acre of cropland than a typical Corn Belt ration. In a 106-day test, steers full-fed chopped cornstalks and a supplement of linseed oil meal, urea, minerals, vitamins, and live yeast yielded 627 pounds of gain to the acre of cropland in comparison with 363 pounds of gain per crop acre for the control lot. The control steers were fed a ration of corn, hay, soybean meal, and minerals. Feed composed of corncobs, cornstalks, or hay supplemented with linseed meal, urea, distiller's grain, molasses, minerals, and vitamins produced 566, 537, and 297 pounds of gain per acre, respectively.

The cost per pound of gain on the animals fed cornstalks and corncobs was 21 to 35 percent less than on the lot full-fed on corn. Each steer received 2 pounds of good-quality mixed hay with the cornstalks or cobs. The Iowa station has recently discovered that good-quality roughages such as mixed hay contain an unidentified material that promotes digestion of cellulose by rumen bacteria.

Hormones improve gains of feeder cattle

Several State experiment stations are conducting research with various synthetic hormone and hormone-like compounds to determine their effects on the growth and quality of meat animals.

Testosterone, the male sex hormone, increased beef cattle gains 12 to 25 percent at the Oregon station (coop. USDA) when fed with a ration of rolled barley and chopped alfalfa hay. Feed efficiency was improved, with a saving of about 150 pounds of feed for each 100 pounds of gain. With testosterone, heifers and steers gained at the rate of 2 to 2.4 pounds daily, respectively. The relative percentages of wholesale cuts in steer and heifer carcasses were not affected by the hormone treatment. Results obtained by feeding testosterone in the ration were the same as when the hormone was given by injection.

Slaughter data on 700 beef steers treated with four different hormones by the Colorado station indicate that testosterone was most conducive to fattening. Of these carcasses, 92 percent graded choice compared with 62 percent for untreated steers. Dressing percentage was about 3 percent higher in the testosterone-treated cattle than in the control group.

At the California station, steers treated with stilbestrol, an estrogenic hormone, gained 0.5 pound more per day than untreated steers in the feed lot and sold for $5 to $30 more per head. Steers similarly treated while on irrigated pasture showed no improvement in gain. Heifers showed less response in body gains than steers.

Progress in breeding research

That improvement in beef cattle of the ability to gain weight and to use feed economically can be accelerated through performance and progeny testing of bulls is shown in results obtained by the Texas station (coop. USDA). Among the bull calves tested at this station last year were five progeny of the two fastest-gaining bulls in the 1949 test. Three of these five calves ranked among the top 25 percent, and

a fourth was above average in daily gain. Techniques for performance and progeny testing, now widely used by the experiment stations, are constantly being improved through research.

Records obtained in bull-testing trials by the Oregon station (coop. USDA) indicate that calves which are large at birth are likely to reach slaughter weight earlier and use the least feed. Bull calves gained 15 percent faster than heifers and required about 19 percent less feed (total digestible nutrients) to produce each 100 pounds of gain. There was little or no relationship between rate of gain and type scores at weaning age; hence the conclusion that breeding stock can be selected for rapid gains and good feed economy without sacrificing desirable type.

Other research by the Texas, Wyoming, Colorado, and Ohio stations is directed toward finding some biochemical or physiological measure of genetic differences in gaining ability and feed economy of beef cattle. In studies of the blood characteristics of bull calves, the Texas station (coop. USDA) found that the levels of protein-bound iodine (an index of thyroid activity) were negatively correlated with daily gain in the feed lot, but showed a high positive correlation with feed consumed per pound of gain. Calves making the highest and most efficient gains had the lowest iodine values. Further research is under way to establish the optimum levels of blood iodine for cattle of different breeds and ages, and under varying environmental conditions.

In 196-day feeding tests over a 3-year period, the New Mexico station (coop. USDA) found that compact steer calves required about 4 percent less feed (total digestible nutrients) to produce a pound of gain, and gained 8 percent more in relation to their initial weight than large-type steers.

Early- versus late-castrated steers

The best age at which to castrate bull calves for maximum production of meat at lowest cost has been studied by the Ohio station. Results to date show that weanling calves fed as bulls for a period of 252 days gained about 12 percent more per day at 8 percent less cost than steer calves. Although the bulls had slightly lower dressing percentages than the steers because they had heavier heads and hides, they yielded a 3.8-percent higher portion of edible meat. Steer carcasses carried considerably more finish than bull carcasses and showed a 5-percent higher fat trim. The meat from bulls and steers was found to be equally tender when aged for 15 days. Steers castrated at 1 month or 6 months of age made similar records with respect to rate and cost of gain and carcass quality. Late castration of calves will allow breeders to do a better job of selecting young bulls for breeding purposes.

Swine

Needs of weanling pigs for amino acids

Single-stomached animals such as the pig are more specific in their requirements for amino acids than are ruminants, which, with the help of the rumen micro-organisms can synthesize any or all of the amino acids needed. Since few protein feeds provide a complete

source of amino acids it is important to know which amino acids are needed by the pig, and the minimum requirements for each of these, in order that the protein content of the ration may be properly balanced.

Recent experiments at the Indiana station have shown for the first time that the amino acids arginine, leucine, phenylalanine, and valine are required for optimum growth of weanling pigs. Earlier work at the Indiana and New York (Cornell) stations had established the essential nature of histidine, isolucine, lysine, methionine, threonine, and tryptophan for growing pigs. In the latest experiments pigs fed a purified diet containing all 10 of these amino acids, plus diammonium citrate as the source of protein (nitrogen), made an average daily gain of 1.2 pounds.

On an arginine-deficient diet similar pigs gained only 0.7 pound daily, whereas pigs on a phenylalanine-deficient diet barely maintained their initial weight. In the absence of either leucine or valine an average daily loss in weight of 0.2 pound per pig was sustained. Further experiments to determine the quantitive requirements for these four animo acids are in progress.

Role of antibiotics

Discovery of the important growth-promoting effects of antibiotics for swine and poultry has stimulated intensive research by the experiment stations, the Department, and private industry to learn how the various antibiotics actually function in animal metabolism, as well as their limitations, practical possibilities, and long time effects.

Following a re-evaluation of the protein requirements of swine, the Iowa station reports that previously recommended levels of protein for producing market hogs in dry lot can be reduced 2 to 4 percent when the hogs are fed a balanced ration and an antibiotic. Essential minerals and B vitamins (including B_{12}) are important also. Protein levels of 14, 11, and 8 percent for pigs of three age classes—weaning weight to 75 pounds, 75 to 150 pounds, and 150 to 200 pounds—produced gains equal to any of three higher levels when supplemented with 10 milligrams of aureomycin per pound of ration. Pigs receiving the antibiotic gained about 10 percent faster and consumed 23 pounds less feed per 100 pounds of gain than control pigs. Carcass yields, depth of back fat, and percentage of lean were not significantly affected by the antibiotic or protein content of the ration. The lower protein levels could save hog producers in Iowa alone the estimated sum of $34,500,000, annually.

The Michigan station obtained equally good growth in pigs by adding terramycin to rations containing 18 or 15 percent of protein. Terramycin improved the rate of gain in pigs 21 to 37 percent, and increased the efficiency of gain at all ages from weaning to slaughter. The response was greatest, however, during the early growth period.

It is believed that antibiotics may promote growth by favoring development of intestinal flora that synthesize growth factors or inhibit undesirable organisms. The Illinois station reports that chloromycetin fed with a synthetic milk diet temporarily reduced the number of coliform bacteria found in the feces of baby pigs reared in wire cages, but that after 10 days the bacterial count was normal. Aureomycin had no effect on numbers of fecal bacteria. Both chloromycetin and aureomycin gave good growth response.

The Georgia station did not find any correlation between growth rates of pigs and bacterial count when they were fed penicillin or streptomycin with corn-soybean meal ration in dry lot. Penicillin seemed to increase total bacteria, whereas streptomycin had no effect on bacterial count. Both drugs were effective in improving the growth rate and the feed efficiency of the pigs.

If an antibiotic is fed to lactating sows some of it is transmitted to the milk, but not in sufficient quantity to benefit suckling pigs, according to the Iowa station. However, a practical method of supplying antibiotics to baby pigs has been developed by the Arkansas station. Bacitracin pellets implanted in the skin of suckling pigs at 2 to 5 days of age increased their weaning weights as much as 11.3 percent over their nontreated litter mates. In this experiment a 1,000-unit level of the antibiotic was more effective than 2,000 or 4,000 units.

Contrary to results obtained at most stations, the North Dakota station reports that tests made on weanling pigs with four different antibiotics and drugs failed to produce any significant improvement in growth rates. Pencillin, bacitracin, terramycin, and an arsonic acid were used in these experiments. The results indicate that environmental conditions may be an important factor. The addition of aureomycin to an 8-percent protein ration for growing pigs proved unprofitable at the Montana station; however, sows on rations supplemented with this antibiotic during gestation and lactation farrowed and weaned more pigs than the control lot.

A new growth stimulant

Tests conducted by the Michigan station with a surface-active agent indicate that it may have an "antibiotic-like" effect in swine rations. Gains of pigs fed a balanced ration in addition to the detergent were equal to those of pigs receiving the same ration and an antibiotic. Both lots gained at the rate of 1.3 pounds daily. As yet there is no explanation for the growth-promoting properties of the compound.

Physiological factors

The Illinois station has conducted a fundamental study to determine the physiological causes of genetically different growth rates in two lines of Hampshire swine. Pigs of the rapid-growth line consumed more than twice as much feed daily and gained three times faster than those of the slow-growth line. At 180 days of age the average difference in weight of the two lines was about 62 pounds.

Anterior pituitaries of pigs from each line slaughtered at different ages were assayed for growth-hormone potency by injecting some of the pituitary powder into rats from which the pituitary glands had been removed. The assays showed that the more rapid growth of one line of pigs was accounted for by the fact that the pituitaries of these pigs secreted more of the growth hormone. Another interesting discovery was that 57-day-old pigs had as much growth hormone per unit of pituitary tissues as they did when fully grown. The physiologists concluded that growth in animals stops when they reach maturity because the amount of growth hormone secreted in relation to body weight is no longer adequate to maintain growth. Future research on this problem may reveal practical means for controlling growth of animals.

Of the 30 percent of pigs born each year that never reach market, more than 1 million die soon after birth from chilling. A study of the effects of chilling on body temperature and blood changes of pigs up to 3 weeks of age by the Michigan station shows that the body temperature regulating mechanism of the new-born pig is only partially developed. A temperature drop of 3° to 13° F. in baby pigs was observed during the first 30 minutes after birth, after which there was a gradual return to normal. The period of adjustment was about 2 days at a temperature of 60° to 75°, although 10 days' adjustment was required at freezing temperature. Pig weight at birth was highly correlated with the ability of the pig to adapt itself to its environment. Small pigs that did not have access to the sow's milk quickly chilled. Chilling of pigs 1 to 2 days old generally resulted in a decrease in blood cell concentration and an increase in blood sugar content. By providing warm quarters for sows at farrowing time, farmers can greatly reduce baby pig losses.

Breeding better hogs

By developing superior inbred lines and systematic methods of using them in crosses, swine breeding research is providing the means for achieving greater efficiency and obtaining better quality in pork production.

Results obtained from linecrossing and cross-breeding trials by the Minnesota station (coop. USDA) show that the increase in litter size, survival rate, weaning rate, and rate and economy of postweaning gain was greatest in cross of strains that were least related. The favorable influence of hybrid vigor on pig performance of the cross-bred progeny was more pronounced during the suckling period than after weaning. The advantage of average single crosses over parent lines, for the five factors studied, ranged from 5.4 percent for a narrow cross to 13.5 percent for a wide cross. Crisscrosses and rotation crosses were 13.03 and 13.83 percent superior, respectively, to parent stocks. Rotation crosses of lines that differed most genetically were 4.5 percent superior to narrowly divergent rotation crosses.

Litters from Duroc gilts mated to inbred boars of different breeds by the Ohio station were heavier at 150 days of age, required less feed per 100 pounds of gain, and yielded leaner carcasses than outbred or rotation line cross Durocs. In the 1951 trials, litters by inbred Poland, Yorkshire, and Landrace-Poland boars from Duroc gilts averaged 9.1, 9.4, and 9.8 pigs at weaning and 1,699, 1,611, and 1,747 pounds in weight at 150 days. Outbred and rotation line cross Durocs weaned 8.4 and 8.5 pigs per litter that weighed 1,409 and 1,502 pounds at 150 days.

In a 4-year study conducted by the Wisconsin station (coop. USDA and farmers), topcross gilts sired by inbred boars produced and weaned more pigs and heavier litters than conventional matings. The difference in favor of gilts by inbred boars amounted to slightly more than 1 pig per litter at farrowing and weaning, and about 37 pounds in weight of litters weaned.

Sheep

Although sheep and wool production in the United States declined severely between 1942 and 1950, research by the State experiment sta-

tions and the Department is pointing the way toward increased and more efficient production. For example, research has shown that the breeding cycle of sheep can be broken so that sheep raising can be fitted more methodically into a planned program of farming operations. Developments like these, and the greater emphasis now being placed on producing wool domestically as a defense measure, as well as the improved practices that are being developed from time to time in breeding, feeding, and management, should encourage more farmers in many sections of the country to launch sheep raising as a profitable side line. Following are some of the examples of outstanding results obtained in the past year in sheep research at the experiment stations.

Protein supplements for wintering breeding ewes

Winter is a critical period for livestock and especially for those wintered on the range. Breeding ewes need extra protein, minerals, and vitamins to produce good crops of lambs and wool. Ranchers look to their State experiment stations for sound advice on the kinds and amounts of supplements to feed in order to obtain maximum efficiency and economy under varying conditions.

Studies of the protein requirements of ewes during gestation at the Montana station indicate that feeding a supplement of about 0.3 pound of protein pellets per head daily to ewes wintered on the range will return an additional profit of $3 to $4 per ewe annually. Ewes receiving a pelleted concentrate containing 10, 20, 30, or 40 percent of protein plus minerals and vitamins, weaned 20 to 30 percent more lambs and sheared heavier fleeces with fewer defects than ewes with no supplement. Although ewes on the higher levels of protein made greater gains in body weight during gestation, this difference was not reflected in the production of wool and lambs. Other ewes were wintered on the range, but the margin of profit above feed costs was about the same.

The South Dakota station obtained good results with a ration containing up to 10 percent of urea fed to wintering pregnant ewes. When fed at this level urea was equal to soybean meal as a source of protein (nitrogen).

At the Oklahoma station ewes fed a supplement containing 30 percent of nitrogen in the form of urea responded as well during and after gestation as those fed an equal amount of protein nitrogen in cottonseed pellets. Thus urea can be used in a practical way to extend short supplies of protein feeds.

Physiology of reproduction

Contrary to the opinion long held by physiologists that the nonbreeding season in sheep results from a lack of hormone secretion, the Illinois station found that the true cause is an excess of the follicle-stimulating hormone. This excess results in an unbalance between the follicle-stimulating hormone and the lutenizing hormone. Study showed that a heretofore unsuspected signaling mechanism operates between the uterus and the pituitary gland of the ewe. Artificial "signals" conveyed to the pituitary by the insertion of a small bead in the uteri of normal ewes caused estrus and ovulation to occur at intervals as short as 4 days, in contrast to the normal interval of 16 days.

Difficulty is frequently encountered in getting ewes to breed during hot weather for early lamb production. The Kentucky station reports

that ewes kept at an enviornmental temperature of about 45° F. during the summer months came into estrus 8 weeks earlier than other ewes maintained under natural conditions. Also semen of rams kept at this temperature did not show the usual summer deterioration in quality. When this semen was used to inseminate ewes early in the breeding season the percentage of conceptions was more than twice that obtained from other matings.

The research also indicates that the occurrence of high temperatures early in the breeding season frequently causes early embryonic death loss in ewes. Shearing summer wool growth from rams and ewes before the start of the breeding season and preventing the exposure of rams to high temperatures may help to increase the size of the early lamb crop.

Improvement through breeding

Results of an 8-year experiment by the West Virginia station, in which western grade Corredale ewes and native grade Hampshire ewes were mated to Southdown rams, show that the western ewes produced 18 percent more lambs and 39 percent more wool than the native ewes. Because of the interest shown by farmers in this experiment, western ewes are being shipped into the State in increasing numbers each year.

The Montana station (coop. USDA) is emphasizing improvement of Rambouillet sheep by inbreeding and linecrossing. In 1951, a cross of two lines produced 6 pounds more lamb per ewe than the average of the parent lines. Fleece weights of cross-line ewes averaged about 15 percent heavier than those of the original inbred lines.

For 4 years, the Texas station has been cooperating with sheep breeders of the State in a performance and progeny testing experiment to improve selection of breeding stocks. Sire groups, each consisting of four ram lambs handled under uniform feeding and management practices, are tested for ability to gain rapidly and to produce heavy fleeces of long-staple wool. Records are based on an 8-month feeding period. To date 576 rams and ram lambs owned by 36 breeders have been tested, and breeder interest is steadly increasing. Progeny of superior rams tested in this experiment have ranked well above the average, which indicates that this is a practical method of sheep improvement.

From original crosses of Rambouillet ewes mated with Border-Leicester and Cheviot rams, the Minnesota station is developing a new strain of sheep especially adapted to northern Minnesota. The sheep are white-faced, hardy, and produce high-quality lambs. Favorable reports from farmers using rams of this strain indicate that they are making a worth while contribution to sheep production in that area.

POULTRY RESEARCH

Total egg production in the United States increased 60 percent during the last decade. In 1951 the rate of lay per hen was 40 percent higher than the 1935–39 average. Production of poultry meat in 1951 was nearly double that of the prewar level, mainly because of the heavy increase in commercial broiler production. In the same year there were 85 percent more turkeys raised than in 1940. Ex-

amples of experiment station and departmental research in poultry production are here presented.

Improved Poultry Through Breeding

Mild inbreeding undesirable

Mild inbreeding with an inbreeding coefficient (brother-sister mating) of 25 percent or more is an unsound practice when 1,000 or fewer birds are involved, according to research at the New Jersey station. An attempt was made to maintain and improve three pure lines by inbreeding and selection, but after the coefficient of inbreeding reached 25 percent the lines began to deteriorate and one became extinct. Inbreeding was discontinued; however, because of the small number of remaining good birds it was not possible to reconstitute or bring these lines back to normal production. When they were crossed, the offspring from the crosses showed an increase in production over the pure lines, but their production was no higher than in random-bred and selected lines. The knowledge gained in this experiment should prevent small poultry breeders from attempting to inbreed poultry in this manner and thereby losing money.

Crossbreeding for better chickens

Between 25 and 50 percent of the laying hens in the Northeast are crossbreds, primarily the result of mating Rhode Island Red males with Barred Plymouth Rock females. This cross is popular with the hatcherymen since the resulting female chicks can be distinguished from the male chicks at a very early age by the difference in color pattern of the feathers. However, because of the lower production and viability of the parental females, the chicks are more expensive to produce than those from reverse crosses. After 5 years of research the New York (Cornell) station showed that mating Barred Rock males to Rhode Island Red females produced at least 7 percent more eggs on the average than mating Rhode Island Red males to Barred Rock females. Although crossbred chicks showed no advantage in viability over purebreds, the former grew more rapidly and began to lay at an earlier age than the latter.

Two new poultry breeds have been developed by the Indiana station. Systematic crossings were made of one strain of Dark Cornish possessing excellent breast fleshing with five strains of Barred Rocks, each excelling in one or more characters, such as feathering, growth rate, or egg production, and one strain of White Rocks excelling in egg production and possessing the dominant white plumage. One breed (barred type) has been released to commercial poultrymen as the Purdue Bar; the second (white dominant) will be released in 1953. These new breeds at present excel in both body feathering and fleshing qualities, are almost as rapid in growth as the best of the commercial broiler varieties, and will lay somewhat better.

At the Pennsylvania station one family (No. 10) of inbred birds had such low fertility that few birds were reared. Consistently poor results were obtained from one particular male of this family, when mated with his sisters and half-sisters, but high fertility resulted when this same male was crossed with females of another family (No. 6). Crosses were made between family 10 and family 6 and males

from family 6 were mated to random-bred stock to produce topcross progeny. The egg production of the topcross progeny has been excellent. During a test period of 120 days, these birds had an 80-percent production as compared with a 74-percent production for the best pen of random-bred birds.

Developing nonbroody chickens

A nonbroody line of Rhode Island Red chickens developed by the Massachusetts station has shown complete freedom from the broody instinct through three generations. This is strong evidence that the line is now genetically free from genes for broodiness. Through the use of conventional methods of line breeding and trapnesting prior to 1947, the incidence of broodiness had been reduced as low as 1 percent, but could not be completely eliminated. Final eradication was accomplished by injecting all females with the hormone prolactin, and selecting as breeders pullets which exhibited little or no reaction to the hormone test.

Physiological Advancements

Multiplane turning increases hatch

Early work at the Iowa station (1930) and the Department indicated that multiplane turning of eggs will increase the hatch. Present research at the Missouri station verifies these early findings. Turning eggs in an incubator in six different positions or on several planes, rather than in the two conventional positions used in nearly all of the modern incubators, will eliminate much of the loss from dead embryos during the later stages of incubation, according to the Missouri station. Multiplane turning reduced the percentage of embryos developing with head-between-thighs, feet-over-head, and beak away from the air cell. There was a relative decrease of 73 percent in the embryos with head-between-thighs. A 3-percent better hatch occurred among multiplane-turned eggs than among eggs turned only in the conventional way under identical conditions in the same incubator. The chicks from the former eggs hatched several hours earlier than those from the latter, were "fluffed out" sooner, and in general appeared to be in better condition.

Pretest hens for poor fertility

The New York (Cornell) station discovered that hens whose eggs show a low fertility usually are able to maintain live spermatozoa in their reproductive tract for a comparatively short period, only 1 day or less. Hens with high fertility can maintain spermatozoa under the same conditions for 14 days or more. By pretesting the females it is possible to eliminate those in which duration of fertility is low. A peculiar aspect of this problem is that males of the infertile strain show unusually precocious sexual maturity, and have large combs that lop over when the animals are as young as 8 weeks. Coincident with this condition the animals show excessive development of the testes. These abnormalities are apparently associated with excessive activity of the anterior lobe of the pituitary in immature birds.

More eggs from dubbed pullets

Research at the Wyoming station indicates that it will be possible to obtain increased egg production without increasing the feed consumption of the birds through the process known as dubbing. Large combs and wattles are susceptible to frostbite and often freeze badly. Dubbing consists of removing the combs and wattles of the birds when they are about 12 weeks old to prevent this trouble.

Dubbed White Leghorn pullets laid 16 percent more eggs through the fall and winter than their sister pullets that were not dubbed. Through the months of February and March, these pullets produced 12 eggs for each 6.5 pounds of feed, whereas those with normal combs and wattles required 10.5 pounds of feed to produce the same number of eggs. Similar results with other breeds and crossbred chickens at the station were obtained but they were not so pronounced. There was lower mortality and higher hatchability among the dubbed birds.

Blood groups help to determine reproductive fitness

According to the Texas station there are four different families of blood group characters in chickens that reflect hereditary biochemical differences in the protein structure of their blood cells. By comparing the performance of chickens with these different blood types, it is possible to determine whether the blood group genes also affect characters of economic importance. One of the families of blood group genes appears to be especially important for selection of the birds to be used as parents in the development of inbred lines. Up to the present time all inbred lines examined have possessed two or more members of this blood group family. This is contrary to expectation and indicates that chickens possessing two members of this blood group family are superior in their reproductive qualities to those that are pure for any one member of the group.

The blood groups may also be used in checking paternity in pedigree breeding work and in the characterization of inbred lines to avoid contamination of one line with another, through error in classification. Furthermore, chicks can be pedigreed from hens mated to more than one male. Such matings should facilitate the collection of critical data on selective mating and may increase the efficiency of the technique followed in the procedure of reciprocal recurrent selection, now becoming important in the field of poultry breeding.

Feeding for Profit

Corn and milo for hens

Laying hens fed an all-mash ration in which all of the oats and one-half of the standard wheat middlings were replaced with ground yellow corn utilized their feed much more efficiently than those fed the standard ration. In four of five experiments at the Storrs station (Connecticut), birds on the high corn ration laid more eggs, had a higher egg hatchability, and weighed more at the end of the laying period than those on the standard-type ration.

In seeking a more economical grain to use as a scratch feed in the laying ration, the New Mexico station compared milo sorghum with

a mixture of corn, wheat, and oats. The cost of the milo at local prices was $1.50 less per 100 pounds than the cost of the mixed grain. The hens whose scratch feed consisted of milo alone produced just as many eggs as the birds fed the more expensive cereal mixture. Since both groups consumed approximately 50 pounds of scratch feed per bird per year the saving with the milo-fed group amounted to 75 cents per bird per year. For the 1,000,000 laying hens in New Mexico, this saving to the State's poultry industry would amount to a total of $750,000 annually.

Source of calcium in eggshells

Radioactive tracer experiments with small animals at the Florida station have resulted in new and important findings. Chickens, given large doses of calcium 45 and phosphorus 32, proved to be much more resistant to the effects of radiation than other species. An egg laid 15 minutes after the feeding of calcium 45 was extremely high in radiation, showing that the calcium in the eggshell is chiefly derived from the immediate daily diet. The radioactive calcium and phosphorus were excreted from the body cells principally into the duodenum. Reabsorption of calcium occurred, however, throughout the intestinal tract, especially in the lower ileum. Chickens also reabsorb calcium from the cloaca, differing in this particular from rats and rabbits.

Amino-acid requirements of growing chicks

Using an original forced-feeding technique, the Illinois station has determined the requirements of growing chicks for certain essential amino acids. Ten and 15-day old male crossbred chicks fed a ration with a minimum protein content of 20 percent needed the following levels of the five critical amino acids in order to make an average daily gain of 8 percent: Arginine—1 percent of ration, lysine—0.8 percent, methionine without cystine—0.65 percent, methionine with 0.5 percent cystine—0.35 percent, and tryptophan—0.2 percent.

A ration supplemented with methionine significantly increased the efficiency of feed utilization by chicks both in batteries and on litter-covered floors, and improved the growth rate as well, in tests made at the Storrs station (Connecticut). It is estimated that this improvement in efficieny of food utilization and growth rate could result in a saving of about $4 per ton of feed in a high-energy corn-soya ration supplemented with methionine.

Molasses and sugar in hen and chick rations

Wood sugar molasses can be used to advantage as a feedstuff for laying hens, the Oregon station reports. When fed to hens in the amount of 7.5 percent of the ration to replace an equal amount of cereal grain, the wood sugar molasses increased egg production and hatchability. Hens ate the molasses readily and their condition compared favorably in every way with hens not fed molasses. Although an initial mild diarrhea was noted in hens given molasses, it was overcome with no apparent ill effects. A higher level of molasses, 15 percent, however, caused egg production to decrease, and the droppings to become heavy and sticky.

Low-grade sugar, also known as third-strike sugar, is potentially available in great quantity in Hawaii since it constitutes approximately

25 percent of the sugar crystals processed from cane juice. When this material was substituted by the Hawaii station for one-half, three-fourths, and all of the cereal grains in the ration of laying pullets, optimum survival, feed consumption, body weight, egg production, egg size, and egg hatchability resulted. Thus, in areas of the world where cereal grains are either not grown or are unavailable, as in Hawaii during prolonged shipping strikes, low-grade sugar may serve successfully as an emergency source of carbohydrates.

In two experiments conducted by the Arkansas station, the substitution of corn molasses (Hydrol) for 10 pounds of corn (dry-matter basis) in 100 pounds of chick diet, increased the rate of growth significantly. It also increased the efficiency of feed utilization 0.2 pound of feed per pound of gain. There is evidence that corn molasses contains an unidentified growth factor for growing chicks.

A byproduct of desugared beet molasses, obtained in the manufacture of monosodium glutamate and glutamic acid, was found by the Colorado station to be an effective source of methyl groups in chick starting mashes low in choline. Feeding this product at different levels in the ration consistently improved the rate of growth of the birds.

Recent findings about antibiotics in rations

According to the Pennsylvania station the growth rates of chickens and turkeys can be increased to 10 percent by the inclusion of 5 grams of aureomycin or terramycin per ton of starter mash. The advantage gained by the addition of one of these antibiotics to the turkey starter mash can be maintained only by adding it also to the grower mash. When the antibiotic was added as a supplement to the feed until the poults were 28 weeks of age the body weight of turkeys increased significantly. Most of the increase occurred in the males, but the hens were significantly more uniform in weight than the toms. Removal of the antibiotic when birds were 8 weeks of age decreased the rate of growth and increased the variability of growth from the twelfth to the twenty-eighth week.

At the Texas station penicillin, bacitracin, and sodium arsanilate have been shown to increase chick and poult growth. Growth increases that can be attributed to the antibiotics, ranged from 10 to 25 percent. In addition to increasing growth, antibiotics have been found to improve feathering in poultry, to make the flocks more uniform, and definitely to improve feed efficiency. Egg production and hatchability have been shown to increase 5 to 8 percent when antibiotics were fed to laying stock.

Recent research at the California station has produced a possible explanation of the growth-promoting effect of antibiotics on poultry. It may be that the drugs inhibit a normal gut microflora that stores up in its own body growth factors from the feed and thus deprives the chicken of an adequate supply of nutrients. At the same time it appears that indiscriminate use of antibiotics in poultry feeding could change the gut microflora to such an extent that drug-resistant pathogenic forms become predominant and thus result in hazards to both the birds and human beings.

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Several unidentified growth factors under investigation

Previous investigations at the Maryland station have shown that at least two unidentified growth factors are involved in the nutritive requirements of poultry. One of these factors is present in liver and certain other products, whereas the other is found in dried whey products. Several concentrated fractions of the liver factor have been prepared, one of which had 350 to 400 times the potency of the original liver product (Biopar C). Growth curves of chicks fed the fractions indicated that there are either two forms of the same unidentified growth factor, or two different factors, one of which is present in two forms with slightly different solubility properties. Poults fed a soybean meal-corn ration fortified with all known nutrients responded to crude supplements, including Biopar C, liver L, fish meal, dried whey products, butyl molasses solubles, butyl grain solubles, and dried brewers' yeast. Although all these products were effective in stimulating growth, only certain ones prevented an enlarged hock disorder, indicating that different factors are involved.

The Iowa station found that supplementing a soybean protein basal diet for chicks with either crude corn oil, refined corn oil, soybean oil, wheat-germ oil, oleic acid concentrate, or linoleic acid concentrate stimulated chick growth as much as 30 percent. The oleic acid concentrate was superior to other oils in promoting growth. The chick has a dietary requirement for either specific fatty acids, or for an unknown vitamin or vitamins present in vegetable oils, or both.

Niacin corrects leg disorders in ducks and turkeys

Pekin ducklings kept on wire-mesh floors and fed practical rations at the New York (Cornell) station showed a severe bowing of the legs. Fish-liver oil was not necessary to produce a high incidence of the disorder. The condition appears to be caused by a niacin deficiency, and was entirely prevented either by feeding 5.0 to 7.5 percent of dried brewers' yeast or adding 20 grams of synthetic niacin per pound of ration.

The Cornell station also found that the omission of the supplementary niacin from the basal diet previously used in the studies of enlarged hock disorder in turkeys resulted in a marked increase in the incidence and severity of enlarged hocks in poults. The addition of 5 percent dried brewers' yeast to a ration to which no niacin had been added failed to prevent the disorder completely, but the addition of 20 grams of niacin per ton of diet with the 5-percent yeast, gave complete protection. At least one unidentified factor is needed in addition to niacin to prevent enlarged hocks.

Grassland economizes on feed

Previous experiments at the Michigan station revealed that the feed consumption of pullets on Ladino clover pasture is 10 percent lower than that of pullets on bare ground. Present research indicates that an additional 10 percent can be saved where pullets are allowed on pasture, and that an over-all saving of 20 percent of other feed is possible. Assuming that the carrying capacity of 1 acre of good pasture is 400 pullets, it is estimated that savings on the feed bill of an acre of poultry pasture is worth $53.

The Vermont station, after 4 years of trials, showed that each acre of pullet range saved about 1,150 pounds of purchased feed annually. With 500 birds per acre the range-reared pullets ate an average of 29.8 pounds of feed whereas the confinement-reared chickens ate 32.1 pounds. The difference of 2.3 pounds represents a saving in purchased feed of 7.2 percent, which more than offsets the costs of range shelters, water piping, and the moving of the birds to and from range. Range-reared pullets were more uniform, had firmer muscling and carried a deeper pigmentation than confined pullets. Fewer of the birds that had been on range had to be culled at housing time, but the nonculled birds in both groups—those on range and those confined—were similar in weight, egg production, and rate of survival. Ladino clover was superior to bluegrass-orchardgrass mixture for late summer pasture in three respects: (1) It yielded considerably more, (2) it was eaten more readily by the birds, and (3) it was capable of carrying a larger number of birds per acre.

The amount of palatable forage that should be available for grazing was found by the Pennsylvania station to differ according to the kinds of birds being grazed and the season of the year. Expressed in terms of dry matter per acre, production of forage ranged from a high of 952 pounds in late July to a low of 28 pounds in mid-September, after a prolonged drought. The total amount of forage available as dry matter on each acre for turkey grazing during the 1951 season was as follows for each grass: Orchard—2,597 pounds, Kentucky bluegrass—2,072 pounds, reed canary—1,898 pounds, and brome—1,594 pounds. The results confirm the findings of six previous years, namely, that approximately twice as many pounds of turkey were produced where pastures were heavily grazed as where they were lightly grazed. On the same orchard grass pasture area 150 turkeys per acre were grown successfully for seven successive years.

High energy rations for breeders

The use of high energy rations for breeder pullets may lower production costs and increase profits, as it has done in broiler rations, according to research at the New Hampshire station. Five rations varying in energy content above 820 calories and up to 977 calories per pound increased egg production from 9.1 to 21.27 percent, and improved feed efficiency from 6.02 to 6.68 pounds per dozen eggs, as compared with the 1949 New England College Conference high-fiber low-energy breeding ration of 820 calories, on which the feed efficiency was 7.07 pounds of feed per dozen eggs. Rations near the midpoint of the energy range gave better results than the highest or lowest energy rations.

Egg Quality Investigations

Egg position during cooling and holding has a greater bearing on the candled quality of eggs than the type of container, according to the Michigan station. Albumin quality is not closely correlated with candled quality. Eggs held in a wire basket maintained the best albumin quality but were next to the lowest in candled quality. Leghorn eggs contained fewer spots than did the brown-shelled eggs from American breeds. Detection of spots is more readily made after eggs

are several days old, although some spots disappear with age of the egg, particularly at relatively high temperatures.

The Missouri station has determined that it is possible to bring to the consumer an AA quality egg if the air cell is not used as a criterion of quality. Of the eggs broken out during July and August, 1951, 70.9 percent scored A quality or better. It is evident that the air cell size has little importance in the grade determination of the edible egg.

DAIRY PRODUCTION

The number of dairy cows in the United States has remained almost constant for over a quarter of a century in spite of the increased awareness of our people of the importance of dairy cattle in converting grass, hay, and silage into nutritious dairy products. Low labor returns and long hours with little opportunity for relaxation have made dairying less attractive than other fields of agriculture. Only through increased production per cow, therefore, has the demand for dairy products been satisfied. With a rapidly increasing population and the growing need for milk, the development of methods by which dairy cattle producers may save time, reduce costs, and improve quality is needed in order to insure enough milk for everyone's needs. Following are representative examples of the type of research now being carried on at State experiment stations with a view to making dairying more attractive to the farmer.

Calves

Dairy herd records for a period covering 44 years summarized by the Nebraska station show that despite every effort made to do a good job of rearing young calves, 12.14 percent died from disease before they were 3 months old, 1.71 percent died between the ages of 4 and 6 months, inclusive, and 0.92 percent died between the ages of 7 and 23 months. These data will prove useful in comparing modern methods of management with earlier practices.

Wisconsin has tried to evaluate various environmental factors on milk production, such as condition at time of calving, length of dry period, efficiency of feed utilization, nutritive ratio of the ration (proportion of digestible protein to digestible nonnitrogenous nutrients), etc. Although the procedures are too involved for a farmer to use in attempting to "correct" a record for these factors, they give the scientist a basis on which to formulate practical recommendations the farmer can use.

The function of vitamin B_{12} and aureomycin in calf nutrition is still unsettled, although aureomycin has proved valuable in controlling scours. Experimental calves at the Arkansas, Kansas, Iowa, Pennsylvania, Oklahoma, Louisiana, and other stations seemed to grow faster when fed aureomycin. The New York (Cornell) station reports that calves fed antibiotics required about 9 percent less feed per unit of gain than calves receiving no antibiotic. However, when the use of aureomycin was discontinued the calves at the Oklahoma station dropped below normal in rate of growth. The Minnesota, Michigan, and Kansas stations showed that aureomycin is a definite handicap to calves after the rumen has begun to function (characteristic bacterial flora is well established) particularly with respect to the digestion of roughage (the crude fiber portion).

According to the Michigan station, large amounts of antibiotics inhibit the growth of certain types of rumen flora; however, in in-vitro trials they found that very low concentrations of penicillin and certain other antibiotics, except chloromycetin, stimulated the growth of cellulolytic rumen micro-organisms. The Illinois, Michigan, and Vermont stations obtained best results when the calf starter contained both aureomycin and vitamin B_{12}. The substitution of cobalt for vitamin B_{12} has not proven successful for young calves, although supplying cobalt to older ruminants appears to stimulate the synthesis of vitamin B_{12} in the rumen (by increasing the growth of certain bacteria). The feeding of vitamin B_{12} does not relieve cobalt deficiency symptoms, according to the Wisconsin station. (Antibotics have not affected milk production, altered feed consumption, or been transmitted into the milk of cows, according to the New York (Cornell) station.

Calves fed a vitamin-D-deficient diet at the New Hampshire station developed the known symptoms of such a diet—rickets, arched back, large knees, sore joints, and underweight. In addition to these apparent adverse effects on the digestibility of minerals, the calves showed a definite tendency to use protein less efficiently, indicating poor digestion and inefficient absorption.

The Ohio station has previously reported good results from "inoculating" young calves with the rumen flora of mature animals. These added micro-organisms are suposed to make it possible for the calves' rumen to digest roughage quicker than when the animal is allowed to develop its own flora in the natural course of time, around 2 to 3 months of age. In the Ohio experiments fresh cud material was used. The Wyoming station now reports that commercially prepared dry cud sold for this purpose has very little value. Up to 8 weeks of age calves at the Oklahoma station grow equally well, irrespective of whether they received any hay or not. And up to 16 weeks of age either good quality alfalfa or timothy hay gave comparable results.

Radioactive Isotopes in Dairy Research

Numerous stations are using radioactive isotopes to unravel the intricate physiological processes involved in converting roughage and certain inorganic compounds into meat and milk. The problem of the digestibility of a feed is sometimes complicated by the fact that certain fragments may be absorbed into the bloodstream, used by the body, and then re-excreted into the gut. By means of "tagged" (radioactive) compounds the California station found that a cow on a high food intake digested only 12 percent of the phosphorus in her ration, according to former measurements of digestibility. With the new method 50 percent of the phosphorus in the feed was shown to have served the body in one way or another. Another cow on a low food intake excreted even more phosphorus in her feces than she consumed in her feed, but when radioactive P^{32} was given the results proved she had used 64 percent of the ingested phosphorus before returning part of it to the gut.

The Florida station, using a slightly different technique, found that on a high calcium, low phosphorus diet insoluble calcium phosphates are formed in the lower part of the intestine, thus preventing the body from utilizing badly needed phosphorus.

Roughage

An abundance of high quality roughage must be fed to dairy cattle throughout the year to insure economical milk production. With this in mind it is necessary to determine what crops will produce the largest amount of good forage throughout the growing season and what is the best way to preserve forage for use during the winter or when growth is slow.

The Michigan station has made a very extensive study of the effect of soil fertility on the nutritive value of the crops grown thereon. Several years' research on the amino acid composition of milk proteins did not reveal any evidence that the nutritive value of feeds is chiefly dependent on soil fertility. According to preliminary data there seems to be very little correlation between the level of various elements in milk and the composition of pasture plants. Ohio's results substantiate those at Michigan.

The Kansas station fed cows a ration in which the entire roughage was made up of finely ground No. 1 dehydrated alfalfa in pellet form. These cows yielded milk markedly lower in butterfat than those fed a ration containing long hay. Farmers are cautioned by the Oklahoma station to keep the amount of ground hay in the concentrate mixture to a minimum. The Wyoming station obtained slightly more milk from cows fed chopped alfalfa than from those fed with long hay, but the increased labor involved did not pay for the cost of chopping.

For many years it has been known that the digestibility of a roughage was closely related to its lignin content. But lignin is not a distinct chemical compound and cannot be determined quantitatively by any simple chemical procedure. During the year the New York (Cornell) station has found that the methoxyl content of forage is an even better index of the digestibility of a roughage and that digestibility can be readily measured by present known chemical methods.

The Iowa station has demonstrated conclusively the essential nature of the fermentative processes normally occurring in the rumen (first stomach) of mature animals. When feed was placed directly in the abomasum (fourth or true stomach) without first undergoing fermentation in the rumen, the animals scoured, became weak and unthrifty, and lost weight, so that the experiment had to be terminated in 10 days.

Michigan station scientists have attempted to measure quantitatively fermentation processes normally occurring in the rumen. Although it has been known for some time that the bacteria in the rumen can use certain nitrogenous compounds commonly thought of as fertilizers, such as urea and inorganic ammonium salts, these scientists have shown that the amount of true protein in the rumen increased as much as 78 percent as the result of the synthesis by the bacteria of these simpler nitrogenous compounds into proteins suitable for nourishing the animal.

The Pennsylvania station discovered that liquid SO_2 (sulfur dioxide) proved very effective in developing the desired acidity for proper preservation of silage. The rapid rise in acidity resulting from the use of 5 to 7 pounds of SO_2 per ton of green material reduced carotene and protein losses to a minimum.

A ration containing silage preserved with SO_2, tested at the New Hampshire station, caused greatly increased synthesis of thiamine in

the rumen of animals to which it was fed. From 60 to 70 percent of the SO_2 consumed is eliminated by the kidneys. The retained sulfur can be used in synthesizing the protein of milk.

The Pennsylvania station also fed bulls grass silage at the rate of 4 pounds per day per 100 pounds of body weight, without adversely affecting the quality of their semen. At the current prices of feed the bulls fed only hay and silage were maintained at an average cost of $15.50 per month, whereas those fed hay and grain cost $19.50 per month.

Pearl millet, if pastured when it is not over 8 to 10 inches high, is one of the best early supplemental pastures for the southern dairyman, according to the Mississippi station. The Georgia trials favor Starr millet.

Merker grass produced a better quality and higher tonnage silage in trials at the Puerto Rico station than either guinea or para grass. Earlier trials there showed that immature sugarcane or sugarcane tops were superior to either of these grasses for silage.

The New Hampshire station studied the problem of feeding hay of low vitamin D content to dairy cows. The vitamin D content of the first cutting of Ladino and bromegrass hay was appreciably increased by irradiation with an ultraviolet light. Timothy and red clover, however, did not respond to this treatment. It was comparatively easy to double the vitamin D content of the second cutting of grass hays, but irradiation had little effect on second cuttings of ladino and clover hay.

Reproduction

Reproductive troubles in dairy cattle were at one time thought to be caused primarily by pathological bacteria. Now it is known that protozoa and certain virus infections may also cause abortion or failure to breed regularly. Research concerning these types of reproductive disorders were discussed under the veterinary section (p. 65). Only breeding troubles that it is thought are caused by nutritional deficiencies or endocrine imbalances, or those possibly genetic in nature will be discussed here.

A new test for pregnancy has been announced by the Oregon station. Many cows remain unbred for weeks and possibly months because of silent heat periods, loss of calf in early pregnancy, or for other reasons. The Oregon station developed a simple test that farmers can use without technical assistance to determine within 95 percent accuracy when a cow is pregnant. If this test is substantiated in further trials, the station expects to recommend it to dairy farmers in an effort to reduce a loss of about $5,000,000 now suffered in Oregon annually as a result of delayed conception in dairy cows.

The Pennsylvania station has developed a very accurate technique for determining the concentration of spermatozoa per milliliter of semen by the use of a colorimeter. The value of this technique is at once evident since the New York (Cornell) station has recently shown that the conception rate in cows drops rapidly when sperm concentration falls below 5 million per milliliter. Louisiana's findings were quite similar to those of New York.

According to the New York (Cornell) station progesterone administered at the beginning of estrus shortens the estrus period and causes ovulation to occur earlier than normal.

Results obtained by the South Dakota station suggest that it may not be long before any cow can be brought into heat on a specified day. This would make it possible to obtain special matings not now feasible where semen of the desired bull is not readily available.

The Michigan station has been able to cause unbred cows to produce as much as 80 pounds of milk a day by the implantation of suitable hormones, namely diethylstilbestrol and progesterone placed under the skin in the form of slowly dissolving pellets. This research emphasizes that the method is still in the experimental stage but that the results obtained probably indicate the inherited capacities of the animals on which the hormones have been tested.

The Oregon station has studied the influence of low carotene (low vitamin A) diets on reproduction and milk secretion. The heifers on the lowest carotene intake had about twice the amount of breeding difficulties as those on normal carotene intakes and produced only about half as much milk after freshening.

According to the Alaska station, heifers came into heat much more regularly in the winter when they were exposed to artificial light than when they were not exposed to it.

Bulls

The North Carolina station kept some of its herd bulls in experimental rooms where the temperature was accurately controlled and maintained over extended periods. Preliminary results indicate that continuous exposure to temperatures above 85° F. may seriously affect a bull's reproductive capacity.

Terramycin and aureomycin tend to reduce the viability of bull semen according to the Arkansas, Pennsylvania, and New Jersey stations. The Pennsylvania station recommends penicillin and streptomycin used singly or in combination for improving the reproductive efficiency of low-fertility bulls.

The Pennsylvania station also advocates the use of boiled milk as a diluter for bovine semen used in artificial breeding associations. Such a diluter is cheaper and easier to prepare than the egg yolk-buffer diluters now in common use. This has been true both in the field and in the laboratory. Preliminary trials with the new diluter have also been favorable at the Vermont station.

Temperature

Many of the Southern States are becoming interested in breeding cattle that are less influenced by high temperatures than native cattle. The Louisiana station (coop. USDA) found that purebred Holsteins and Jerseys are just as efficient in their ability to graze as Sindhi-Holstein and Sindhi-Jersey crossbred animals, as long as the environment temperature does not go above 87° F. and the relative humidity is around 52 percent. At temperatures above 87° the crossbreds appeared to graze more readily than the purebred Holsteins and Jerseys.

The Missouri station found that over a period of 3 months the hair on Brahman cattle, as it changed from dark to white, increased in reflecting power as the temperature of the environment gradually increased. The hair of the Brown Swiss did not show increases in reflecting power until the temperature went above 85° F. Attempts

are now being made to learn whether this may be one of the more important reasons why Brahman cattle are better adapted to hot climates than European cattle. The station also found that high humidity does not seriously influence milk production until the temperature reaches 80°. Increasing the temperature from 60° to 100° reduced the thyroid activity of dairy cattle (another problem solved with a radioactive compound—I^{131}).

DAIRY INDUSTRY

Investigations by dairy departments at State experiment stations include research of importance to everyone in the dairy industry. Some of the most fundamental research now being carried on is in the fields of dairy chemistry and dairy bacteriology. For example, by means of a process known in physical chemistry as electrophoresis one of the stations recently isolated a new protein found only in the membrane of fat globules. This protein may provide the key to the solution of the problem of oxidized milk. Such findings are of great importance in carrying on other research leading to advancement in dairy manufacture and technology, the practical results of which are summarized below.

New Findings on Handling Processed Milk

One of the most critical steps involved in the processing of whole milk powder is homogenization. Efficiently homogenized milk used in the production of whole milk powder will reconstitute much more readily than milk less efficiently homogenized. The Washington station found that low fat milk will homogenize more efficiently than high fat milk and that the reconstituted product will give maximum wettability values. Fourteen-percent butterfat milk powder will keep better than whole milk powder and is more desirable for beverage purposes than nonfat milk powder. The Wisconsin station established the fact that moderate-size dry milk particles (around 26.3 microns in diameter) are more soluble than either finer or coarser fractions. The Indiana station succeeded in increasing the solubility of milk at least twentyfold by adding certain surface-active agents before the milk was dried. According to the Minnesota station the flavor and keeping quality characteristics of freeze-dried milk are essentially the same as for spray-dried whole milk powder. Both became tallowy during storage.

The Minnesota and Pennsylvania stations learned that beta- lactoglobulin is the main source of sulfhydryl groups in milk and that this protein is primarily responsible for the cooked flavor in milk. The Minnesota station emphasizes that the sulfhydryl groups are not responsible for the poor baking quality of improperly dried milk. At the Missouri station evaporated milk was allowed to age for various periods and under various temperatures in electrolytic and hot-dipped plated cans. After a 50-day storage period the amount of tin dissolved in the milk has increased from 50 to 79 parts per million when the temperature was increased from about 75° to 98.6° F. After a 340-day storage period the tin content of the milk had increased from 115 to 210 parts per million. Evaporated milk as received contained about 20 parts per million of tin. The milk gradually became darker

and separation took place as the storage time increased. The inside surfaces of the cans showed increasing pitting, general detinning, discoloration, and staining. No significant increase was noted in the concentration of iron, copper, or lead in the milk.

The relative immunity of homogenized milk to oxidized flavor is reported by the New York (Cornell) station to be due to the pieces of fat-globule membrane being drawn into the interior of the fat-globules. There it is effectively protected by the antioxidant normally present in milk.

A study of the tocopherol or vitamin E content of milk has been completed by the Iowa station. Values varied from 16 to 54 micrograms per gram. The seasonal trends follow more or less the trends for vitamin A—highest in August through October, lowest from January to March, rising in the spring and dropping in late fall. The tocopherols appear to be chiefly alpha in the spring and summer, with the slower reacting tocopherols (beta and gamma) increasing materially in late fall and winter. The amount in the milk is quite important since tocopherols are essential for normal reproduction in certain animals. It also prevents a certain type of nutritional muscular dystrophy. When added to milk and similar compounds it behaves as an antioxidant.

Ascorbic acid is much more efficient than tocopherol in preventing the development of an oxidized flavor in frozen cream, the Oklahoma station says. In cream stored for long periods in the frozen state, all levels of ascorbic acid tried helped to reduce the intensity of the oxidized flavor, but fortification at the rate of 100 micrograms of ascorbic acid per kilogram of cream was generally necessary to prevent the development of off-flavor.

The Connecticut station has developed an improved procedure, known as sequential grading, of fresh milk. This method permits rapid acceptance of "good" milk or rejection of "poor" milk with more careful study given to "borderline" milk. The major advantage is that an examination of fewer microscopic fields gets as accurate or better results than are possible with the more complicated procedure used heretofore.

Research Aids Cheese Manufacture

A white mutant of blue cheese was discovered by the Minnesota and the Wisconsin stations. The Minnesota station now announces it has been able to successfully spray-dry both the blue and the white types of Roquefort cheese. The dried white cheese had a pleasing cheese flavor, light tan or cream color, and good solubility. The dried blue cheese had a gray green color, but not as pleasing a flavor as the dried white cheese and it was not as soluble as the white cheese. Research indications are that these products can be used to advantage in dehydrated mixes such as dry salad dressing and other food preparations.

The Pennsylvania station has developed a new use for over-ripened blue cheese, no matter how strong its flavor. The cheese is melted down and extracted with a vegetable oil of the type used on salads. The oil is emulsified with water containing salt, vinegar, and other flavoring to yield a complete and naturally flavored Roquefort-type dressing.

The Wisconsin station has perfected a device for mechanically measuring the firmness of cheese curd. It can be used on a wide range of products from Romano to typical cheese spreads. It is expected that it can be applied commercially in standardizing the slicing properties of process cheese, judging the firmness of fresh cheese, evaluating the rate of body breakdown of cheese during curing, and selecting cheese for specific market requirements.

The Indiana station conducted studies to determine the relationship between the production of lactic acid in miniature Swiss cheese and the degree of characteristic sweet flavor. The results provide a guide for the control of flavor and eye formation. The data indicate that a definite amount of lactic acid must be produced in the cheese since the sweet flavor comes from fermentation of lactic acid by the propionic acid bacteria.

The Montana station has found that the addition of 0.008 percent of citric acid to pasteurized skim milk before inoculation with culture increased the volatile acids and flavor compounds sufficiently to improve the flavor and quality of cheese.

Biacetyl in milk improves the flavor of cottage cheese made from it, according to an Oregon station study. Samples with high biacetyl content received high flavor scores although occasionally some samples were criticized for high acid. The station also reports that in general the soluble protein fraction of milk has an important influence on starter activity. Paradoxically, the milk from animals on a low carotene diet was apparently normal in protein composition but failed, nonetheless, to properly support starter activity.

No practical method has been found for inactivating antibiotics present in the milk of a cow recently treated for mastitis. From 60 to 80 percent of the aureomycin remained in a series of test samples after milk was autoclaved for 10 minutes at 15 pounds pressure at the Virginia station. This clearly shows that antibiotics, such as aureomycin, cannot be inactivated by exposure to pasteurizing temperatures.

In experiments at the Minnesota station aureomycin added to milk suppressed certain undesirable types of bacteria, but allowed other equally undesirable types to multiply, thus nullifying any advantage gained by using the antibiotic.

Cream Studies on Improving Butter

An undesirable cheesy flavor in butter can usually be traced to contamination with *Pseudomonas putrefaciens* bacteria according to the Minnesota station. Adding 1.5 percent of salt (on the basis of the amount of skim milk present) to the churning contaminated with this organism has tended to prevent surface taint in the resulting butter. The excess salt is washed out in working the butter.

Neither the acidity of the cream at time of churning nor the kind or type of commercial neutralizers commonly used to standardize acidity content of cream has any appreciable effect on the carotene and vitamin A content in fresh butter or in butter held in cold storage, according to research carried on by the Montana station.

Improving the Efficiency of Sanitizing Agents

Metallic equipment in dairy manufacturing plants continues to present problems that will eventually be solved through new discoveries in chemistry. For instance, such elements as iron, copper, zinc, nickel, and others used in the manufacture of vats, tanks, pipes, and dairy machinery create different trace reactions when milk, water, and solutions containing cleansing compounds pass through the equipment. Considerable research on the role of quaternary ammonium germicides in such reactions has recently been done by the Massachusetts station. The station's research confirms the theory that any metallic cation will interfere with the quaternary ammonium germicide by competing for the negative sites on the cell surface of germs (bacteria). It was shown that quaternary ammonium compounds lose their effectiveness (germicidal value) in direct proportion to the amount and valence of the interfering metallic cations present in so-called hard water. Monovalent, divalent, and trivalent ions, respectively, have interfering power in the approximate ratio of 1:100:10,000. The cations arranged in order of decreasing interference are aluminum, iron (ferric), copper, zinc, nickel, manganese, barium, iron (ferrous), magnesium, calcium, and the monovalent cations.

Some of the modern washing agents that quickly remove dirt and destroy bacteria also corrode the metal surfaces of dairy equipment and thus cause heavy financial losses. The Michigan station found that chelating salts improve the detergent action of certain wetting agents but that they cause excessive corrosion unless inhibited by such materials as sodium meta-silicate and boric acid salts. This type of information is most valuable to the companies preparing washing compounds and to the users of dairy equipment.

Cracked Liners Increase Bacteria Count

The Kansas station has found that when the inner surface of the rubber teat cup liners to the milking machine becomes covered with fine cracks it is almost impossible to obtain a low bacteria count milk, even though these cracks are so fine they can be seen only with a low power microscope. Such liners, in over 150 comparisons under practical and laboratory conditions, gave counts of from 5 to 100 times as high as new liners or liners with little surface breakdown.

FOODS

Food Storage and Processing

The full benefits of increased food production can be realized only if there is concurrent development of food storage and processing techniques. Technological developments, such as those noted in the following examples, lead to twofold gain: First, they insure conservation of an increased quantity of seasonal surpluses of food crops; and, second, they insure improved retention of quality and nutritive value in the foods as processed and stored.

Retaining color and quality in glass-packed foods

Studies at the Massachusetts station have shown that the browning in many strained baby foods is caused by the presence of oxygen in the food jar, and that added ascorbic acid helps to reduce the oxygen. If sufficient improvements can be made in preventing gaseous diffusion through closure gaskets, the addition of ascorbic acid to strained foods at economically feasible levels may result in the inhibition of discoloration in these foods during a normal shelf life.

In studying the role of the enzyme peroxidase in the development of off-flavor and undesirable color and aroma in fresh cucumber pickles, which now have an estimated commercial value of about 10 million dollars, the Massachusetts stations found that off-flavors in pickles increased markedly during storage at 35° F. as compared with the increase during storage at room temperatures. This was prevented by the use of a pasteurization treatment under temperatures high enough to reduce the peroxidase activity to a low level.

Bottled-milk delivery and home storage

The West Virginia station studied the keeping quality of pasteurized bottled milk in home refrigerators under summer conditions. After being subjected to the customary delivery and home handling methods, samples of the milk were returned to the station for laboratory testing. Control samples kept in the laboratory scored consistently higher in flavor and increased less in acidity and bacterial count than did the milk returned from cooperating families. Absorbed flavors of the milk stored in home refrigerators were traced to the wide variation in handling. Uncapped bottles and caps improperly placed, as well as delayed refrigeration of the milk, were responsible for the inferior flavor in the home-stored milk. Flavor was satisfactory up to 3 or 4 days after delivery, but decreased sharply after 5 or 6 days. Delivery every other day or three times a week was found to be sufficient with good pasteurized milk when distributors and consumers used reasonable care in handling.

Nutritive Value of Foods

American homemakers as a whole are eager to learn more about the nutritive value of foods in order to make more intelligent selection of the diet. This has prompted studies like the one summarized below.

Ascorbic-acid content of different orange juices compared

The Illinois station determined the ascorbic acid content in freshly reamed and strained juices from California and Florida oranges obtained on the Illinois market over the 1950–51 season. Market samples of the processed juices were also analyzed—the canned juices as taken from the can, and the canned concentrated and frozen concentrated juices after dilution with 5 and 3 cans of cold water, respectively. Thus prepared, the fresh juice from California oranges averaged 0.51 milligram of ascorbic acid per gram of juice; all the other juices were much alike in ascorbic acid values which ranged from 0.39 to 0.42 milligram per gram. Although the fresh juice reamed from the California oranges was higher than the other juices in

ascorbic acid value, it also cost more—approximately 7.8 cents per 3.5 ounce serving at the then current market prices as compared with costs ranging from 3.7 cents to 4.4 cents per serving for the other juices.

Judges who rated the juices considered the fresh juices more palatable than the frozen, and the frozen more palatable than the canned or canned concentrated juices.

Food Consumption

Facts concerning the food consumption and the dietary habits of population groups are essential in estimating the potential demand for various foods, and in determining whether families are well fed according to current nutritional standards.

Family food consumption in the South

Data on food consumption of farm families in the Southern region are presented in a recent report of the Arkansas, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia stations (coop. USDA). Cotton, tobacco, and mountain farming areas were represented by the 731 farm families selected for participation in the study. Each family kept a 1-week food record and supplied other pertinent information. The records covered in detail the family's consumption of various foods within the general classes of fruits; vegetables; meats, fish and eggs; grain products; fats and oils; and sugars and sweets.

Analysis of the records revealed that food patterns in the three areas were different in many respects. The use of milk, for example, was greatest in the mountain area, least in the tobacco area. In the cotton and tobacco areas where Negro families as well as white kept records, the milk consumption of the Negro families averaged roughly half that of the white families. In all areas it was apparent that if families did not have home-produced milk they used comparatively little.

In terms of money value, cotton area families spent more for purchased foods than did families of similar race, tenure, or income in areas where more home-produced foods were used. For example, white farm owners in the cotton, tobacco, and mountain areas spent an average per week of $10.60, $8.95 and $6.89, respectively, and used home-produced foods valued, on the basis of farm prices, at $11.40, $12.35, and $14.36, respectively. White sharecroppers in the cotton and tobacco areas spent about the same amounts per household as did white owners, but the average value of their home-produced foods was less than half that of white farm owners in the same area.

Estimates of the nutrients furnished by the week's food supply showed that many of the farm families failed to get enough calcium, ascorbic acid, and vitamin A value to meet the allowances recommended by the National Research Council. Large proportions of Negro families and families with relatively low income and very limited supplies of home-produced foods had diets low in these nutrients and often deficient in protein and riboflavin. Riboflavin deficiencies of the diets, and likewise any deficiencies in thiamine, niacin, and iron, would have been still more pronounced had it not been for the liberal use of enriched cereal products.

The survey showed that increased use of milk and of green and yellow vegetables, potatoes and sweetpotatoes, and tomatoes and citrus fruits were needed to improve the quality of these family diets. Such improvement calls not only for better home food production and conservation, but also for more intelligent choice of foods obtained by purchase.

HUMAN NUTRITION

If human welfare is to be a more prominent consideration in the planning of agricultural programs, the dietary needs of people, both rural and urban, must be taken into account. To obtain reliable, factual information on this subject, the State experiment stations in all four regions have undertaken comprehensive regional nutritional status investigations.

Nutritional Status of Boys and Girls

Regional research

In the several regions, children have been among the subjects selected for intensive study. In the Western region, for example, the Oregon station (coop. USDA) has completed a study of 739 native-born and reared 14-, 15-, and 16-year-olds. As part of the investigation, special attention was given to the dental caries among this group. Other stations in the Western region (coop. USDA), namely, Colorado, Idaho, Montana, New Mexico, Utah, and Washington, have also included children in their surveys, with emphasis on particular local nutrition problems. In the North Central region, the Iowa, Kansas, and Ohio stations (coop. USDA) have studied about 3,000 boys and girls in grades 1 to 12 in selected areas of the three States, with special reference to the role of the school lunch on the nutriture of the children. In the Northeast region, 968 adolescents, 762 pre-high-school children, 195 high-school students, and 604 college students have been included as subjects in the nutritional status investigations of the Maine, New York (Cornell), Rhode Island, and West Virginia stations. In the Southern region, the interest has centered in 8-, 9-, 10-, and 11-year-olds. The Louisiana station (coop. USDA) has just reported on a study of 478 Louisiana boys and girls and the Virginia (coop. USDA) and Georgia stations have studies in progress on selected groups in these States.

These studies differ in detail and emphasis, but are adding up (1) to give an enlightening picture of the nutritional status of children in selected areas across the country; (2) to augment the fund of information necessary for establishing standards for appraising the level of nutriture of population groups; and (3) to determine the relative merits of the several methods for assessing nutritional status.

With the importance of methods in mind, all regions have made a three-way approach to the investigations. This has involved, for each subject studied: (1) A complete dietary record, usually for a 7-day period, with calculations in terms of nutrient intake; (2) physical and microchemical measurements, including, respectively, those for height and weight, and for certain nutrient levels in the blood; and (3) clinical records pertaining to any signs of malnutrition.

The following discussion, with selected examples, will give a few of the pertinent facts being found in these regional studies, and will point up some of the implications for the growing science of nutrition.

Dietary records

Dietary records obtained in the surveys were calculated into terms of nutrient intakes. These were compared with the recommended daily allowances of the National Research Council, to give presumptive evidence of the nutritional adequacy of the diets. The Kansas investigators, for example, estimated that half of the diets of the children studied were inadequate in ascorbic acid and calcium; Iowa workers also noted that ascorbic acid and calcium were the most frequent deficiencies. In the Louisiana study, the children were found to have a fairly good mean nutrient intake; more than 60 percent met the National Research Council's recommendations for dietary allowances for all nutrients except ascorbic acid, for which only 21 percent met the recommended allowance. In the Oregon group over 60 percent of the children had diets adequate in all nutrients except iron and ascorbic acid; for these two nutrients, respectively, only 41 and 43 percent of the children had adequate intakes. New York (Cornell) investigators observed that ascorbic acid, and also calcium, fell below the recommended daily allowances more often than did calories or any of the other seven nutrients studied.

There was some evidence that younger children had better diets than the older children. In the Louisiana group, for example, a much larger percentage of the 8- and 9-year-olds than of the 10- and 11-year-olds met or exceeded the recommended allowances. Results of the dietary studies by the New York (Cornell) station indicated that about 55 percent of the children 13 years of age or more had nutrient intakes below those recommended by the National Research Council, whereas 40 percent of the 10- to 12-year-olds, 30 percent of the 7- to 9-year-olds, and only 20 percent of the 4- to 6-year-olds had nutrient intakes lower than these recommended allowances.

Blood findings

Past research has built up considerable evidence to indicate that hemoglobin values and blood levels of certain nutrients are influenced by nutrient intake, among other factors. Blood values associated with good, fair, and poor nutriture have not, however, been definitely established, although a classification proposed by Bessey and Lowry, on the basis of a study of 1,200 children, is frequently used for reference in appraising the nutriture of subjects in that age group. When rated by the Bessey-Lowry classification, the majority of the children studied by the Oregon station had high values for all the six blood constituents determined, with the exception of serum carotene, in which about 50 percent of the children were classified as "fair." A considerable number of subjects studied, however, rated low for several of the blood tests. More than 45 percent of the entire group of Louisiana children studied met the "good" levels for hemoglobin and serum vitamin A, carotene, and ascorbic acid. The data from these studies showed differences with respect to sex and age in the levels of certain of the blood constituents, as well as interregional and intraregional differences.

Clinical signs

A report summarizing the clinical findings from the survey of individuals in the Northeastern region, indicates that clinical signs, possibly related to nutritional deficiencies, were observed among the children studied. The school children observed in Maine were reported to have generally higher incidences of these clinical signs than were found in other groups. Physicians cooperating in the Louisiana study observed that about 12 of the clinical signs associated with nutritional deficiencies occurred in 20 percent or more of the children. No clear-cut relationship was found, however, between clinical manifestations and nutrient intakes or blood levels. The evidence from these studies suggests that too much significance cannot be attached to clinical findings alone, since many individuals may have subclinical deficiencies, as indicated by the blood and dietary findings, without exhibiting visible physical signs.

Methods

The regional investigators are not ready to make definite conclusions as to the relative merits of the three methods used in assessing nutritional status. Experience to date, however, has confirmed earlier observations that dietary surveys per se are time consuming and costly. Such surveys, moreover, present many problems, as indicated in recent reports of the studies in the North Central and Northeast regions. Medical examinations have proved useful in giving a more complete picture, but have been found to have important limitations. The newer microchemical techniques for determining blood nutrients were easily and economically employed and appear to have great potentialities in assessing nutritional status, particularly in detecting the beginning stages of malnutrition.

HOUSING

Through cooperative regional research data have been gathered and facts established that will be helpful in carrying out programs designed to make the farmhouse more useful or livable. The aim of the several regions in studying housing has been to obtain information that can be put to use in promoting family health, comfort, and safety. Reports on housing surveys, similar in scope to those previously issued for the Northeastern and North Central regions, have now been published for the Southern and Western regions, thus rounding out the Nation-wide picture of what farm families prefer in housing.

Southern Rural Housing

New designs and improved plans for the construction of functional rural houses are being developed for the Coastal Plain, Piedmont, Mountain, Plateau, Interior, and Alluvial subregions of southern United States. These plans are based on information obtained by personal interviews with 1,507 homemakers in owner-operator farm families. Alabama, Arkansas, Georgia, Mississippi, South Carolina, Tennessee, and Virginia stations (coop. USDA) secured the information on the kind and scope of activities carried on in farm homes;

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kinds and quantities of possessions requiring storage in the house; preferences for locations of activity areas and features of construction; and on the houses occupied by the families and how they were used.

Special household activities mentioned by the homemakers included certain phases of meal preparation (baking and buttermaking), meat cutting, lard making, food preservation, meal service, entertaining, laundering, sewing, and business activities. The porch was the place preferred for preparing food for preservation by almost two-thirds of the women. In the mild climate of the Coastal Plain, more than half of the women washed out of doors or in a separate building the year round. In other subregions the kitchen was used more than any other place in winter; many transferred this activity to the porch, a separate building or, in the summer, to the yard.

Most of the houses occupied by the families studied were one-story frame structures, with a median of five rooms and one or more porches. Only 18 percent had bathrooms and 33 percent had running water. Seventy-two percent of all the houses had electricity. Wood was used more than any other fuel.

According to the survey, three out of four of the families wanted a one-story house. In the Mountain and Piedmont regions, families preferred houses of more than one story and houses with basements. Two porches, a separate dining room, kitchen-dining area, and a special guest room were the choice of most families. Special features desired were open fireplaces, windows over the kitchen sink, some windows low enough that small children could look out, and a sheltered area for drying clothes in bad weather. More and better storage arrangements were requested by the majority of the homemakers.

Custom-made houses are more expensive than many families can afford. The survey information, however, is being translated into a wide variety of house plans. From these the Southern family may select the home which represents the best available combination of structural features.

Western Rural Housing

To find out just what western farm women would like in the way of housing, 1,100 farm housewives were asked what features they would include if they could redesign their homes. Answers to this and other questions were obtained to help house designers plan houses for western living. The work on the survey was conducted by the Arizona, California, Colorado, Montana, Oregon, Utah, and Washington stations (coop. USDA).

In keeping with the traditions of the wide open spaces in the West, farm homemakers in the region wanted more room. They wanted big kitchens, for example, at least large enough for two people to work there at a time. This was especially true for families of five persons or more. And most of them also wanted space enough so they could eat in the kitchen. Much of the canning and freezing of foods is now done in the kitchen, but many of the women said they would like to do part of this in some other area.

The western farm women, 94 percent of whom do all or most of their own laundry, preferred to do it somewhere other than in the

kitchen. They also needed some covered area for drying clothes, particularly during the winter.

Sewing is an important activity in many western homes, the survey showed—enough so that planners felt justified in making special provisions for this activity in many of their western home plans.

For the most part, farm housing needs and preferences varied to such an extent that it would be impossible to draw up standard plans incorporating all the features considered desirable by large groups of western families. These families agreed, however, that they would like to have a one-story house with a basement which would provide for food storage, would have room for a furnace if needed, and that might even provide for an extra room. The western homemakers wanted both a front and a back porch—the front one for rest and relaxation and the back one, preferably enclosed, for work and storage. Western preferences also were for a window over the kitchen sink, and a picture window in the living room; and two-thirds of the families surveyed indicated a need for some sort of a business center—a desk and convenient files—where record-keeping and other business activities could be organized.

Western families who could not afford all the space they would like favored a combined kitchen and dining area and a combined living and sleeping room.

RESEARCH IN FARM ECONOMICS

One of the important services expected from State agricultural experiment stations is the gathering of facts and the dissemination of information that will help farmers make most effective use of the resources at hand. It takes land, labor, capital, and effective management to produce farm crops. The successful farmer selects crops and enterprises adapted to local conditions and organizes his farm to obtain maximum net returns over a period of years. State experiment station research in agricultural economics is, therefore, designed to aid farmers in doing a better job in selecting and combining crops and enterprises and in developing principles that will help farmers make long-range plans as well as day-to-day decisions. There are forces and conditions, such as the general level of prices paid and received, taxation, insurance, foreign trade, roads, development of large irrigation and drainage projects, and the availability of suitable credit and its cost, over which the individual farmer has little or no direct control. Yet all affect his individual economy and his success in attaining production objectives. Some of the current results reported by State experiment stations in research in farm economics are summarized below.

Factors Affecting the Profitableness of Dairy Farming

The Vermont station found that dairy farms, better than average with respect to size, labor efficiency, and amount of milk sold per cow, had labor incomes that were $2,248 larger than those whose farms were below average in all three factors. The station found that dairy farmers who fertilized and limed their land had higher labor incomes than those who did not. Farmers using an average of 130 fertilizer

units per acre (fertilizer units are pounds of available plant food in commercial fertilizer) had hay yields of 2 tons per acre, kept 24 cows per farm, and had labor incomes averaging $1,346. Farmers who used no commercial fertilizer had hay yields of 1 ton per acre, kept 15 cows, and suffered a loss of $370. As the amount of fertilizer used increased, the labor income increased but at a decreasing rate.

Maryland station research showed that on farms near fluid milk markets where land and labor costs are high, it is advisable to keep more cows, to grow the roughage, and to purchase a high percentage of the grain. Such factors as the market to which shipped, size of business, the volume of dairy production, the quantity of other livestock produced, crop production, utilization of labor and machinery, and the combination of enterprises carried out on a farm were found to affect profits. Farms shipping to Washington made the greatest profits; those shipping to Philadelphia and Baltimore stood second and third, respectively, in extent of profits. The average size of farm was 186.4 acres and the number of cows 30.6. The average farm income was $3,115 and interest on investment was $2,148, which left an average living income of $967. The most profitable group of farms obtained a labor income of $6,019, whereas the least profitable group had a loss of $3,745. Herds were larger in the most profitable group and milk production per cow averaged 8,813 pounds. For the least profitable group milk production averaged 7,100 pounds per cow.

In a study of the relation of seasonal variation in milk production to costs and returns, the Mississippi station learned that profit per cow averaged $25 higher on farms stressing winter production.

A Michigan station study (coop. USDA) showed that the adoption of improved feed production and feeding practices could result in a 500- to 800-pound saving in protein and grain feed per cow and a 15-percent reduction in the cost of feed per 100 pounds of milk produced. The average Michigan dairyman who operates a 1-man farm with average producing cows, could increase his labor income by about 80 percent through improved breeding and culling practices, thereby increasing production per cow from 7,000 pounds to 10,000 pounds of 3.5 percent milk. A 2-man farm with no change in quality of cow would result in no greater increase in labor income. The dairyman who is successful in improving both the quality of his cows and his production practices can expect to triple his labor income.

The Delaware station reports that the average cost per pregnancy for artificial insemination for New Castle County dairy herds was $5.33, slightly less than the average cost of grade-bull service which was $5.69. The cost of bull service per cow varies with the size of herds. The cost of artificial insemination per pregnancy for small herds is appreciably less than grade-bull service.

Profitable Crops and Enterprises

The North Carolina station has prepared a series of tables showing the average cost (labor requirements, seedbed preparation, cultivation, harvesting charges, etc.) and returns for the major types of farm enterprises. By a careful comparison of one's own business with other combinations of alternative farm enterprises, each farmer

can determine the most profitable type of farming under his particular conditions. Georgia, New Jersey, Florida, Washington, South Carolina, and many other stations are developing cost data that can be used in determining which crops and enterprises the individual farmer should expand or contract, and ways of reducing cost. The relative profitableness of the different crops and enterprises are frequently found to depend largely upon yields or rates of production.

Profitable farm production depends to a considerable extent on the adoption of optimum combinations in enterprises and resources. The Montana station found that on the basis of the 1950 operations: (1) Increases in cropland per farm in comparison to other resources would have been highly profitable, since returns exceeded the cost of owning land valued at market rates; (2) expenditures in seed and spray showed high returns; (3) in the small- to moderate-size livestock enterprises, feed was used at rates at which increments in returns from feed were slightly less than increments in feed costs.

Obtaining Maximum Use of Resources

A study of the degree to which farms in southern Iowa make use of the resources at their command, reported by the Iowa station, showed that the returns on capital are considerably above interest rates paid on borrowed funds in the area. Farmers indicated that the use of additional capital would return an income greater than the cost of borrowed funds. Farmers gave the following reasons for not using more capital to increase the productivity of their labor and capital: 61.5 percent felt that uncertainty with respect to specific conditions was too great; 9.2 percent looked upon debt as being "bad"; and 2.8 percent were unable to obtain additional credit; whereas the remainder considered health, labor, or tenure as limitations. On many farms it was found that more capital could be profitably used through enlargement of investment in livestock and by improving the soil and crop-production practices.

The Illinois station found that depletion through intensive cropping, rather than erosion, is the big problem on land having less than a 2-percent slope, of which the State has over 7 million acres. Comparison of alternative rotation and fertilization combinations indicate that rotations containing legume catch crops (green manure) on one-fourth and one-third of the land give larger net returns than rotations that do not include soil-building legumes. The former are definitely superior to rotations containing the same proportions of standover legumes. Although many farmers have hesitated to make such a transition because they believed it involved a loss of income during the transition period, it was found that by carefully planning the soil improvements the transition from a continuous corn and soybean rotation to a catch crop legume rotation and balanced fertility program could be made at 1952 price and cost levels without sacrificing net earnings during any year of the transition. The methods used in the Illinois study, it is believed, can be used to obtain higher production and increased earnings from land that is currently producing below its potential.

Economics of Supplementary Irrigation

Increased interest in supplementary irrigation has been shown in the eastern part of the country. The Pennsylvania station in a study of the cost of irrigating field crops, orchards, and pastures, found that the total expense of applying an acre-inch of water was $13.40. On the average, 4.14 acre-inches of water were applied in 2.5 applications. Approximately 1,900 acres of irrigated land were included in the study, 70 percent of which was in potatoes. Farmers' estimates of increased yields from irrigation varied from 10 percent on apples to 40.9 percent on cabbage. Approximately 65 percent of the farmers obtained water from rivers or streams, 17 percent from ponds, and 11 percent from a combination of the two. Fixed costs accounted for 70 percent, and variable costs for 30 percent of the total cost. From farm to farm these costs varied inversely with the amount of water used and the size of fields irrigated and directly with the pressure necessary at the pump. Farmers using irrigation were satisfied with the results and felt that the investment had been justified by its contribution to the farm business.

The Oregon station (coop. USDA) made a study of applying water by sprinkler irrigation on 111 farms in the Willamette Valley in 1950. This study showed that the total cost of this supplemental water application averaged $1.99 per acre-inch. The average irrigation per farm was 33.4 acres. A total of 18.1 acre-inches of water was applied in 6.5 applications during the season. Cost of application was low where systems were used at or near capacity during the critical irrigation period. On farms using their systems at an average of 23 percent of capacity during the critical month of operation, the average cost per acre-inch was $3.11; on those using 50 percent of capacity, $1.84 per acre-inch; and on those using 91 percent of capacity, $1.03 per acre-inch. The costs were divided as follows: Interest and depreciation, 42 percent; labor, 30 percent; power, 24 percent; and miscellaneous charges, 4 percent.

The Texas station (coop. USDA) found that the per acre-foot cost of irrigation water was greatly affected by the yield of the well. High pumping costs were associated with low yielding wells, regardless of the type of power or kind of fuel used. A farmer can control costs to some extent by using a power unit well suited to the pumping load of his well. The total cost of developing and equipping a new irrigation well on the High Plains of Texas during 1947, 1948, and 1949 usually ranged between $4,000 and $5,000.

Farmers Overcoming Labor Shortage With Machinery

The shortage of manpower on the farm brought about by World War II and the continued shortage of labor resulting from job opportunities in industry has emphasized the need for continued mechanization on the farm. The State experiment stations are carrying on research in an effort to find economical ways to perform various tasks with less labor. As a result of the findings of these studies, many farmers have solved the problem by purchasing a greater variety of farm machinery, and the capital investment in machinery has increased.

Surveys made by the Oklahoma station in 1948, 1949, and 1950 showed that southwestern Oklahoma cotton growers who harvested their crop mechanically were saving about $25 per bale over hand-harvesting. Publicity given this information is believed to have resulted in the sale and use of at least 500 more cotton strippers in the State than otherwise would have been the case. In one season alone during which, the records showed, each machine harvested about 40 bales, the savings amounted to one-half million dollars.

In a study of mechanically stripped cotton of the crops of 1949, 1950, and 1951 on the High Plains of Texas, the Texas station (coop. USDA) proved that storing cotton in the seed in the field prior to ginning was a satisfactory method of adapting ginning capacity to mechanical harvesting. Cost of careful piling in the field and reloading to trailers varied from $1.09 to $1.75 per bale, depending on the equipment used. The alternatives are to leave the seed cotton on the stalk and harvest as ginning facilities become available, or to harvest as quickly as possible and transport to distant gins. The cost of either is greater than the cost involved in field storing.

The seed cotton of 1949 and 1950 crops stored in the field prior to ginning did not receive any precipitation of consequence, and when graded was equal to or better than cotton harvested on similar dates and ginned at harvest. Some of the field-stored cotton of the 1951 crop received as much as 1 inch of moisture in early January 1952 but there was no loss in grade. During the 4 years of study, 1947–50, costs of hand-harvesting averaged about $40 per bale. Total cost per bale for operating mechanical strippers (exclusive of field and grade loss) on dry-land farms averaged $9.10 for cotton that had not been previously hand-snapped, and for scrapping the average cost was $20.10 per bale, whereas on irrigated farms with higher yields average costs were $4.50 and $10.85, respectively.

The labor shortage on cotton farms in South Carolina is forcing many farmers to turn from cotton growing to other enterprises requiring less manual labor. In its continuation of the study of the use of mechanical cotton pickers, the South Carolina station (coop. USDA) found that profitable use of mechanical cotton pickers is possible only in operations in which each machine harvested a minimum of 75 to 100 bales of cotton annually. Field waste was reduced to 5 percent on some farms. Based on 1950 prices, field waste amounted to $10.68 per 500-pound bale. Machine-picked cotton was lower in grade than hand-picked cotton. In 1950 the grade loss, based on loan value, amounted to $13.40 per bale. The mechanical picker helps to fill in the labor gaps on the farm caused by the exodus of operators and wage labor to industry, and permits a continuing flow of cotton from the farm to market.

Methods of harvesting grass (hay) silage and field-cured hay were analyzed by the Indiana station from detailed farmer-kept and time-study records on northeastern and central Indiana farms. When the whole process of producing, harvesting, storing, and feeding the forage was considered, it was found that the cost of handling a dry matter ton in the form of grass silage can be made directly competitive with field curing and baling or chopping. On the farms studied, a ton of field-cured material was produced, harvested, stored, and fed for about $14 a ton in 1950, whereas 3.2 tons (an equivalent amount of

dry matter) of grass silage was handled through the entire process with upright silos for about $17 plus the cost of preservative. Labor and storage costs were much lower where trench silos were used.

Effect of Location on Land Values

The Oklahoma station discovered that there is a direct relationship between the price of farm real estate and the condition of the road on which the farm is located. The relation of highways and markets to land values was determined by an analysis of 2,850 actual land transfers in 7 representative Oklahoma counties. The analysis of these transfers showed that on the average, a farm lying within one-half mile of an all-weather road sold for 48 percent more than a similar farm located 2 to 4 miles off such road. The information obtained has proven useful to (1) farmers in buying and selling land, (2) public officials in developing more equitable methods of assessing farm land for tax purposes, and (3) appraisers who must set a value on land as a basis for settling estates, making loans, or in connection with condemnation proceedings.

The Texas station (coop. USDA) points to the importance of the relationship of mineral rights to the price that can be obtained for the sale of land. Studies made in a number of counties revealed that land transferred with 100 percent of the mineral rights brought a price about double that of land of similar quality from which these rights were separated. Where one-half of the mineral rights were reserved the price was depressed relatively little; as a consequence, this practice is becoming widespread.

Agricultural Loans and Interest Rates

The Minnesota station found that 40 percent of total loans and discounts of the rural banks studied consisted of short-term agricultural loans. Interest rates on short-term farm loans varied significantly among type-of-farming areas in the State. The most common rate on these loans was 6 percent in the southeast dairy area and southwest livestock area. In other areas of the State, rates of 7 and 8 percent were common. Rates of interest were found to vary with the size of loan, collateral security offered, and the borrower's repayment ability. Over one-third of the banks had increased their interest rates during the past year. It was found that the bankers varied security requirements on loans, depending on their knowledge of the borrower, the borrower's financial position, size of loan, and other conditions. One-third of the banks intend to exercise more caution in their lending if current war tensions and preparations ease.

The Ohio station made a study of four livestock feeding areas and found that credit agencies desired feeding loans. Only about 15 percent of the commercial banks considered feeder livestock loans undesirable or too risky. Interest rates varied from 4 to 6 percent. The most common rate was 5 percent. The farmer who had established himself as having a good reputation in meeting credit obligations had a little difficulty in getting the credit he desired. It was necessary for some borrowers who were large feeders to secure their financing through the larger loaning institutions, since some of the smaller agencies were limited in size of loans by their capital structure.

Price Knowledge and Farm Planning

The Florida station (coop. USDA) found that early varieties of oranges were higher yielders than midseason and late oranges, but that late oranges sell at a higher price. Thus late and early oranges at comparable ages net the grower approximately the same returns per acre. Midseason oranges usually net less per acre than early or late varieties. Differences in yield between early and late grapefruit are not great, but late grapefruit varieties usually net more per acre and per box. These and similar data are of material assistance to prospective planters of additional acreages as well as to the industry generally.

There is a measurable relationship between total volume of burley tobacco production and burley tobacco prices, according to research carried on by the Kentucky station. Prices tend to: (1) Decrease about 1½ cents for each 10-million-pound increase in production and vice versa, (2) to increase about 2½ cents for each 10 million pounds at burley pledged for nonrecourse loans, (3) to be over one-half cent lower for each 10-million-pound increase in the stock of old-crop burley, and (4) to increase well over 2½ cents for each 10-million-pound increase in disappearance. The station found that the amount of burley tobacco pledged for nonrecourse loans has tended: (1) To increase over 3 million pounds for each 1 cent in price support level, (2) to increase about one-half million pounds for each million-pound increase in production and vice versa, (3) to increase about 150,000 pounds for each 1-million-pound increase in the level of stocks on hand at the opening of the auctions, and (4) to decrease around three-quarter million pounds for each million-pound increase in disappearance. Changes in governmental arrangements, policies among buyers, and the geographic distribution of allotments, as well as extreme pessimism among buyers, or similar influences, are capable of bringing about variations from these estimates.

The Montana station (coop. USDA) found that when prices are falling ranchers tend to hold back marketable livestock as long as possible. This in turn increases the size of the enterprise and causes cash expenditures to be increased or spread over a larger unit. On the other hand, when prices rise, ranchers tend to hold back marketable animals as long as possible in order to increase the size of the breeding band. The lag in time necessary to build ranch bands is about 3 to 4 years. This was the situation from 1938 to 1943. The lag in marketing stock during periods of rising prices, although temporarily deferring cash income, is not as serious to the range livestock rancher as the holding back during periods of declining prices.

In analyzing the hog-corn price ratios for Oregon and the nearest States shipping surplus pork to Oregon, the State experiment station learned that the price of pork in Oregon is essentially the price in surplus-producing States plus transportation costs. The Oregon price is approximately $1.50 per 100 pounds above Western Corn Belt States. Corn in these States is sufficiently lower in price, however, so that 100 pounds of pork are worth about 3 bushels of corn more than in Oregon. Although Oregon producers use very little corn, there is little difference between the price of corn and barley on a feed-unit basis and barley is usually chopped for hogs. With pork at $22 per 100 pounds

and grain at $55.64 per ton, a margin of profit of $3.25 per 100 pounds of pork produced was realized.

After studying the factors determining the price of canned apricots, the California station reported the following findings: (1) A change of 1 million cases in domestic shipments of California canned apricots, with nonagricultural income and with competing canned fruit prices held constant, was on the average accompanied by a change in the opposite direction of about 40 cents a case in the f. o. b. price of canned apricots; (2) an increase of 10 percent in the index of nonagricultural income in the United States, with domestic shipments of California canned apricots and with prices of competing canned fruits held constant, was on the average accompanied by an increase of about 30 cents a case in the f. o. b. price of California canned apricots; and (3) an increase of 10 percent in the adjusted index of prices of competing canned fruits, with domestic shipments of California canned apricots and with nonagricultural income held constant, was on the average accompanied by an increase of about 25 cents a case in the f. o. b. price of California canned apricots.

AGRICULTURAL MARKETING RESEARCH

Economic research in the various fields of agricultural marketing was treated comprehensively in the 1951 Report on the Agricultural Experiment Stations. Such research is being expanded with Federal funds made available under authorization of the 1946 amendment to the Bankhead-Jones Act (formerly referred to as title I of the Research and Marketing Act). There is close cooperation between economists and those responsible for research in the physical and natural sciences, also between the experiment stations and the United States Department of Agriculture. Special emphasis is being directed toward the solution of current and prospective problems, such as ways and means of lowering operating costs and margins; improvement in handling practices and marketing and merchandising methods; prevention of marketing loss and spoilage; and preservation, improvement, and control of quality in an effort to meet consumer preference and to bring about wider acceptance and demand so that market outlets may be further developed and expanded. Detailed examples are here presented of research along these lines.

Prepackaging of Vegetables

Research at the Florida station has shown that celery and sweet corn can be successfully prepackaged and delivered in good condition to northern markets. Prepackaged celery, shipped the same as bulk celery, should be prepackaged at the shipping point. On the other hand, the difficulty and cost of maintaining continuous low temperature for prepackaged sweet corn indicates that the major portion of this crop should be packaged near the terminal markets.

Corn in the husk, not precooled before cold storage, lost 33 percent of its sucrose in the 18 hours required to reach 32° F. air temperature. Rapidly precooled corn lost practically no sugar in 4 days at 32° in husks or in four types of plastic films. Without refrigeration corn in the husk was edible after 4 days, but only 0.3 percent of the sucrose

remained. Prepackaged corn was inedible after 2 days at 81° but retained 0.7 to 1 percent sucrose after 4 days. Sucrose in corn in sealed packages was often double that in ventilated packages at 81°, but high carbon dioxide produced off-flavors. Sugar loss was slower in corn stored at a low temperature and removed to room temperature than in corn with no previous cold storage. Flavor declined at 32° even though there was a slight increase in sugar.

Celery in pliofilm, and in ventilated cellophane, maintained better flavor at high and low temperatures than nonpackaged celery. Stretched pliofilm prevented wilting and was sufficiently permeable to carbon dioxide to prevent the off-flavors found in nonventilated cellophane. The best flavors were found in packages with 3 to 7 percent of carbon dioxide.

Quality of Services in Ginning Cotton

The Arizona station (coop. USDA) reported that weekly cotton samples were collected for 12 weeks during the ginning season from 26 gins in central Arizona in a study made to appraise the quality of ginning services under various kinds of cleaning equipment. Also, some 1,000 listings of cotton sales were extracted from the recapitulation sheets of first sellers. Information recorded include date of sale, producing region, a breakdown of the grades and staples, and variety and "hog-round" prices. The station hopes soon to make grade information available to the farmer.

Effect of Prices on Meat Consumption

The Iowa station found that the elasticities of pork consumption per capita changes as follows: Increases by 0.91 percent when the price of pork drops by 1 percent; decreases by 0.6 percent when the price of beef drops by 1 percent; decreases by 0.87 percent when the price of poultry products drops by 1 percent; and increases by 0.77 percent when disposable income per capita rises by 1 percent. Beef consumption per capita changes as follows: Increases by 0.77 percent when the price of beef drops by 1 percent; decreases by 0.53 percent when the price of pork drops by 1 percent; decreases by 0.67 percent when the price of poultry products drops by 1 percent; increases by 0.65 percent when disposable income per capita rises by 1 percent. Poultry products consumption per capita changes as follows: Increases by 0.68 percent when the price of poultry products drops by 1 percent; decreases by 0.12 percent when the price of pork drops by 1 percent; decreases by 0.28 percent when the price of beef drops by 1 percent; increases by 0.53 percent when disposal income per capita rises by 1 percent.

Marketing Prepackaged Potatoes

Results of an Oregon study (coop. USDA) on the comparative efficiency of marketing potatoes in mesh bags at shipping points and at terminal markets showed that the potatoes packed in 10-pound mesh bags at shipping point had 1.6 pounds fewer grade defects and 1.8 pounds fewer nongrade defects per hundredweight when inspected at the terminal market than did the potatoes shipped in 100-pound bags

to terminal markets and repacked into 10-pound mesh bags. The shipping point 10-pound-mesh bags were packed and made ready for delivery to retail stores in the terminal market at a cost of about 17 cents per hundredweight less than the comparable costs for the terminal market prepackaged potatoes. However, the cost difference shown might not be as important as it would seem since the small-scale repackaging operations studied, utilized labor which, to some extent, would be idle otherwise.

Relation of Egg Marketing Methods to Producer Returns

In a study of egg marketing methods in four counties representing the four major areas of the State, the Maryland station showed that the following factors provide a basis for selecting a good egg market: Price received; difference in cost of egg production; breed of layer; and volume of production. Farmers who sold their eggs to consumers (direct) received the highest average price, 60 cents per dozen, hatcheries paid the second highest price, 58 cents, and restaurants paid the third highest price, 49 cents. Eggs sold to country stores and hucksters brought the lowest prices. The main difference in cost of production is that between hatching eggs and market eggs. It cost about 7 cents more per dozen to produce hatching eggs than market eggs; however, the hatching egg premium generally more than offsets that difference. The choice of a market is sometimes governed by the color of eggs produced and consequently the breed of layer. Hatcherymen in particular want eggs from the heavier breeds, if they sell chicks for broiler production. Large-volume egg producers may find it more profitable to sell their eggs to hatcherymen or wholesalers.

Farmer Patronage of Cooperatives

The Minnesota station reports that in the fiscal year 1949–50 there were 1,341 farmers' marketing and purchasing associations in the State and that these had a gross volume of business totaling over one-fourth billion dollars. Of this total, 538 dairy cooperatives provided $337,000,000 and 232 grain associations provided $554,000,000. Cooperatives in Minnesota reported 773,596 patrons. This indicates that farmers patronized somewhat over four cooperatives each. Data from this study have been requested by such agencies as the Farm Credit Administration and the Joint Congressional Committee on Internal Revenue Taxation.

Marketing of Farm Forest Products

Of some 37.5 millions of acres in Georgia, approximately 25 million are in woods. In a study of woodland economics the Georgia station found that about one-half of the wooded area is on farms. Since farmers sell timber at long intervals, they are not in close touch with prices and markets. A wide variety of forest products, sawlogs, pulpwood, veneer logs, fence posts, etc., are handled. There are no standardized or universally accepted specifications for timber or any of the rough forest products produced and sold in Georgia. The lists of forest product buyers for each county, and data on the products

and species they handled and the specifications they followed, obtained in this study, are expected to be of material help to land owners in obtaining fair prices for their forest products.

Relation of Quality of Products to Consumer Preference

The New Jersey station followed samples of McIntosh apples from the farm to the retail store bins and inspected them for bruises, skin breaks, and stem punctures. More than 50 percent of the bruises and 70 percent of the severe bruises were shown to take place after the fruit left the farm. Thus, much of the damage was beyond the grower's control. The wide range in bruising between the better and poorer samples showed that considerable improvement in handling is possible both at the farm and at the retail store. A study of the consumer reaction to a new sweet corn hybrid—New Jersey 101—was made by asking produce managers and consumers for their opinions; 78 percent of those who made returns stated that it was better than other sweet corn, and only 7 percent reported it inferior. Several improvements in the conventional strawberry crate were made, based on the 1950 study. The improved crate was much more satisfactory and is now being used in many areas.

Factors Influencing Apple Sales

New York (Cornell) station economists have found that more fruit of a given quality is sold by retail stores that simultaneously offer their fruit in both bulk and package form than by those who offer it in only one form. The increased sales were so pronounced in the stores where this method was tried that four national chain store systems immediately modified their merchandising practices. In 1951 about 20 percent of the New York fresh apple crop was packaged in conformance with the findings of this study. The leaders of this study have also developed what appears to be a much more accurate method of evaluating customer preference.

Costs and Efficiency of Dairy Processing Plants

In studying the costs and efficiency of dairy processing plants in Idaho, the Idaho station (coop. USDA, California and Oregon stations), has developed a methodology for analyzing multiple-product plants. The results show that the smaller the butter powder plants the greater is the percentage of capital and labor required, labor representing heaviest expense. As plants increase in size, costs per unit of output decrease more rapidly than the labor costs. As the size of plant increases, the cost of supplies per unit of output becomes relatively more important. In very large plants over 50 percent of the total unit cost is the cost of supplies.

Market News Service for the South Dakota Poultry Industry

An analysis made by the South Dakota station of existing price and market information available to South Dakota poultry and egg farmers through local newspapers and radio broadcasts revealed that local

price quotations are usually historic; often do not correspond to prices that dealers are paying or are willing to pay; and are not comparable among various communities because of the diversity of grades used. The South Dakota findings suggest that the operation of an improved market news service, undertaken by an independent agency, might increase returns to farmers for their eggs, chickens, or turkeys.

South Dakota turkey producers have complained about inadequate local price information which may be a deterrent to increasing production. In an attempt to appraise the advantages of an improved market news service, a weekly Turkey Market Report was issued during the fall of 1951 under this study. This was followed with a questionnaire mailed to turkey growers. The overwhelming majority of the growers responding expressed satisfaction with the reports. The experiences gained could be applied in setting up a market news service for the poultry and egg industry as a whole.

Shipping and Export Tests for Avocados

Research on marketing of avocados at the Puerto Rico station showed that storage at 40° to 50° F. retarded softening and provided sufficient time for shipping and retailing in the eastern United States markets. Waxing did not extend the storage period but reduced moisture loss in some instances and prevented shriveling after long storage. Waxed fruit had better eye appeal than the nonwaxed fruit. No harmful effects of waxing were noted. Oil content increased progressively in relation to the date of harvest. Correlation studies revealed that for the Galo and Nabal varieties 91 percent of the observed total variation in oil content could be attributed to date of harvest, and for the Kanan variety 84 percent. Length of optimum storage period and eating quality can be forecast with precision by means of oil content.

Marketing Texas Livestock

In 1951, the Texas station (coop. USDA) applied time-and-motion techniques to a sample of Texas auctions to determine the best way of performing the basic functions involved in auction selling of livestock. The functions of unloading, tagging, penning, bringing animals up to the ring, selling, repenning, and loading out can be done in several ways. Some methods were definitely superior from the standpoint of speed and use of manpower. A model livestock auction was prepared. It incorporated the best features of all the auctions studied and could be operated with an estimated two-thirds of the labor commonly used by auctions of similar size. Also, many of the delays now common in auction operations could be eliminated. Potential savings of $100 per sales day could be attained by adopting all of the labor-saving features, the Texas station claims. Persons developing new auctions or remodeling existing ones can incorporate selected features of the Texas model.

As auctions have become more efficient and costs of operation have decreased, commissions charged for selling have likewise decreased. This has been brought about by competition for business among auctions. Further rate decreases should come about through the adoption of the features incorporated in the model auction. An additional ad-

vantage of increased efficiency is the time saved for auction patrons. Unloading of consigned livestock can be speeded up to eliminate waiting in line. Volume of sales for cattle can be increased to the rate of 2 or 3 per minute and 150 per hour and sales of sheep and hogs can be increased also. This increased speed is attained by eliminating delays that are common in current procedures. The result is a fast-moving auction that provides maximum service to buyers and sellers at minimum operating costs and time.

West Virginia Homemakers' Preferences for Eggs

The West Virginia station learned that it does not pay to sort individual eggs within the weight limits used in the Federal standards in producing or processing eggs for consumers of West Virginia cities. Homemakers were presented different dozens of eggs. Some dozens contained individual eggs that varied considerably more than run-of-the-nest eggs. Other dozens contained eggs very uniform in size. With a few exceptions, the average homemaker was as apt to show preference for the eggs that varied greatly in size as she was for those most uniform. Evidently producers and dealers could reduce expenses by merely picking out only the extremely large eggs and the extremely small eggs rather than by doing a more precise job of sorting. West Virginia does not have legal standards for minimum weights for individual eggs and evidently should continue to confine such standards to minimum dozen weights. Experimental sales in retail stores and surveys of retailers yielded results in agreement with the homemakers' views.

Costs of Marketing Apples

On the average, according to the United States Department of Agriculture, 78 cents of the consumer's dollar spent for all varieties of Appalachian apples sold in Pittsburgh during the 1949–50 season went to the marketing system and 22 cents went to the grower. The detailed distribution was as follows: Grower, 22 cents; packing and shipping point services, 30 cents; freight, 5 cents; initial receiver and secondary handler, 9 cents; and retailer, 34 cents. The Virginia station reports that the variation in costs of packing shed and shipping point services among firms within a given size group was found to be greater than between size groups. These variations in total costs within size groups ranged from 12 to 54 percent for operators who packed in boxes and from 28 to 55 percent for operators who packed in baskets.

Figures like these, developed through station research, enable the individual grower to analyze his operational and other marketing costs and to compare them with the range and average costs for operators within his size group. This provides a measure of efficiency in his operation and points to possible improvements he should make. Figures on costs and margins at each phase of the marketing process are also available to the industry to guide it in engaging in programs by which it can reduce the margins at various points.

Marketing Feeder and Slaughter Livestock

An analysis of 200 records obtained from cattle ranchers, made by the Colorado station (coop. USDA) showed that there is need for more exact information on prices for various classes and grades of cattle. The average price per hundredweight received for Colorado feeder cattle varies widely from market to market. There is no present method of relating these prices to the quality of livestock sold, except at terminal markets. Since a large proportion of the cattle are not sold at terminals, stockmen are unable to judge accurately their comparative net returns from sales at different markets. The study included operations of a small group of cattlemen who supplied records of their cattle marketings for 2 years. The records showed that about two-thirds of these men tried a different market the second year. Such shifting would not have taken place had they been satisfied with the market outlets available.

RURAL LIFE RESEARCH

Advances made in agricultural technology have greatly increased the capacity of American farms to produce and have also modernized and stepped up the pace of rural living. This accelerated tempo, together with the fact that free lands are no longer available as they were in the decades following passage of the Homestead Act, presents an increasing number of sociological problems. Agricultural experiment stations are seeking to solve some of these problems in the interest of community and State well-being. Some of their researches deal with changes in rural population as affected by vital statistics, migration, and shifts in population as related to resources. Other stations are going into the problems of farm labor and tenure; needs of the special age groups, such as the youth and the old age groups; rural health and hospital requirements; and facilities for meeting the sociological needs of rural people through churches, schools, libraries, meeting places, and recreation. Cultural patterns and urban-rural relations are studied, as are the effects of adopting new practices on the stability of rural communities. Following are a few examples of results obtained in station rural sociology research.

Use of Hospitals by Rural People

The Mississippi station (coop. USDA) undertook a survey on hospital use by rural people in Bolivar, Choctaw, Forrest, and Lee Counties. One of every 18 rural persons in these counties was admitted to a general hospital within a year's time. The average stay was 8½ days. The survey population comprised 3,443 individuals in 909 representative rural families.

The amount of hospital use varied with socio-economic standing, race, age, sex, occupation of the individuals studied, the distance they lived from hospital, and their status with respct to hospitalization insurance. The higher the economic and educational levels the greater was the use made by individuals of the hospitals. Although Negroes were only half as likely to enter a hospital as whites, the total days they were hospitalized, because of their much longer average stay, were similar to the number of days stayed by whites.

The aged of both sexes and women in the childbearing years had the highest rates of hospitalization. Females as a group used hos-

pitals twice as much as males. Farm people were less likely to be hospitalized than nonfarm rural people, and the closer a person lived to a hospital the more likely he was to use it. Persons possessing prepaid hospital insurance were three times as likely to use a hospital as those without insurance.

Need of Developing Resources To Hold South Dakota Youth

The South Dakota station reports that because of its large net outmigration during the past decade the State did not gain in population to the extent that might be expected as a result of its large annual excess of births over deaths. Those who leave the State are preponderantly single youths and young married adults and their children. Because of the continued "export" of its youths, South Dakota has a larger proportion of the aged in its population than has the Nation as a whole. In South Dakota, however, there was an increase in the number of children under 5 years of age and of persons above 55 and a decrease in the number of young and mature adults. That means that the State has now and can expect in the future a growing proportion of dependents in relation to supporters. An extensive program of resources development may therefore be justified on the ground that it is needed to provide opportunities for the youths of the State, to increase and stabilize agricultural production, and to make possible a more satisfying way of life.

Population Changes in Arkansas

The movement of people away from Arkansas continued during the 1940's at an accelerated rate, offsetting the high natural increase of about 300,000 persons, and reducing the total State population by about 50,000. This, according to the State experiment station, represents not only a migration of manpower, but of production capacity and material wealth, that should be a consideration in the establishment of public policy for institutional planning and support. The migrants to other States have higher occupational status and education and are younger than nonmigrants. They leave to a disproportionate extent after they have reached high-school age and the period of dependence on the family and community for support, to spend their productive years in other States, there using the cumulative wealth that they have received through inheritance or in other ways from their connection with the earlier in-State residence and their parental family.

The movements from farm to farm, from farm to urban area, and from urban to urban areas constitute the major streams. The outmigration from Arkansas exceeded the incoming by approximately 450,000, representing an excess of more than 40 percent of persons residing on farms in 1940. For each major movement there is a counter movement which during recent years, whether between farm and nonfarm or between States, has roughly approximated a ratio of 2 to 1; the instability of residence is several times in excess of the rate of net loss. The problem of maintaining adequate local organizations in the small community is complicated not only by the diminished members but by the heterogeneity of interests and service demands that result from the mixing of peoples of dissimilar background and predisposition.

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Growth and Decline of Rural Communities

Conclusions drawn from a study conducted by the Indiana station indicate that certain social and economic factors are positively or negatively associated with growth or decline of rural village communities. Growth was especially associated with the degree of integration of the younger segments of the population into the socio-economic activities of the community; the effectiveness of local leadership in fostering integrated community effort by the utilization of community resources; the vitality of the community's organizations and services; and the alleviation of town-country conflicts. Decline was inversely associated with these factors, plus the inability to meet big-city competition. The size of the community and the actual number of community services were neutral factors and not of major importance in either growth or decline.

Old Age and Retirement in Rural Connecticut

The Storrs station (Connecticut) made a survey and an analysis of the needs of older persons living in East Haddam. Most older residents were self-supporting. Family ties were important in the adjustment process, particularly among foreign-born persons. Nearly one-fourth of the elderly persons lived on commercial farms and many of those with farm backgrounds still carried on some farming activities. The two most pressing problems confronting older persons included in the survey were leisure time and poor health or physical disability. They needed more adequate preparation for retirement, not only financial, but in the areas of health and leisure-time activies. The needs of older persons deserve attention on the part of public and private organizations interested in promoting the welfare of rural people.

Land Tenure and Transfer

Results of the 1950 census taken in Illinois counties and in some counties of adjacent States were analyzed by the Illinois station. They showed that the average area per farm operated by full owners had fallen from 119 acres in 1900 to 93 acres in 1950. Acres per tenant farm had increased from 122 to 202; of part-owners as tenants from 63 to 123. Part-owners as lessees of 16 percent of the land in 1950 and full tenants who operated 44 percent of the land accounted for 60 percent of the State's farm land. The increase of part-owner leasing brought to nearly 80 percent the proportion of the land rented in several central Illinois counties. Full-owner operation was being confined even more to land below the average in value per acre. With land prices 20 percent above 1920 levels, with farms about 20 percent larger, and with the amount borrowable from leading Nation-wide lending agencies seldom above 40 percent of current prices of farm land, the route to land ownership seems not to have been eased, especially in the areas of highest-priced land.

Rural Social Organization

In its report of a study of the general pattern of rural organizations in the State, the Kentucky station stated that an analysis of the objectives and activities of over 500 special-interest organizations in four different counties revealed that the principal reason why people in

these counties set up these organizations was to broaden their education. Nearly one-half reported educational objectives ranging from a more or less routine distribution of information to such highly organized projects as imparting information through demonstrations or classroom-like instruction, and 36 percent reported the carrying on of educational activities.

Religious objectives ranked second to educational and these objectives were followed in order by recreational, relief or welfare, and general community improvement groups. Educational and economic problems were the principal ones confronting people in the more rural counties who put into operation special-interest organizations; whereas religious, welfare, and recreational needs motivated a proportionately greater number of organizations in the less rural counties.

Local Governmental Units and the Natural Rural Community Area

In studying the relationship between local government units and the natural rural-community areas, the Minnesota station learned that there has been a steady increase in the number of incorporated villages in the State from one census to another. From 1940 to 1950, 40 new incorporations took place. The percentage of the State's population living in unincorporated territory has declined from 54.6 in 1890 to 32.3 in 1950. The rural farm population makes up 76.7 percent of those in unincorporated territory. Organized townships have declined in number from 1,973 in 1930 to 1,884 in 1950. Rural ungraded elementary schools have declined from 6,888 in 1932 to 3,599 in 1951, perhaps the most significant trend in the formal structure of the farm community now in process.

Lowered Enrollment in One-Room Schools

The Montana station found that farm migration to town, which is in part a result of and in part concomitant with the increase in size and the decrease in number of farms, is one of the factors causing a decrease in the number of and enrollment in one-room rural schools. Rural community social organizations and activities that once centered in the rural school have disbanded or have consolidated with similar organizations and serve a wider area usually centered in a town or village. Farm families residing in town tend to participate in more social organizations than they did when living on the farm.

The number of one-room schools in Montana decreased 62 percent and enrollment declined 70 percent. Enrollment in town and city elementary schools increased almost 6 percent. An attempt was made to determine the factors involved in the changes in school enrollment in Montana. Actual enrollments indicated that some factor other than births, probably migration in and out of the State, affected school enrollments.

Sociological Aspects of Land Authority Communities

In studying the sociological aspects of land authority communities, established through insular legislative action, the Puerto Rico station reports that the successful community in the sugarcane area owes its improvement, to a considerable extent, to the intensive and continued efforts of the professional leaders. Economically, the success-

ful community is far better off than the unsuccessful one. The participation in social organizations in the successful community is more marked than in the unsuccessful. Dwellers in the successful community in the sugarcane area carry on a more intensive community life than the dwellers in the unsuccessful community. Two community studies in the coffee area show the need of intensive professional guidance for those who dwell there and for the application of special organization techniques appropriate to the agricultural areas.

Adjustments of Youth to a Changing Society

Data analyzed by the Washington station indicated that in spite of the general belief that urban families have become more democratic than the traditionally authoritarian farm families, there is little difference between the attitude of urban and farm families in the State. Families in small towns proved to be the most democratically conducted. To every question on parent-teenage relationship covered by the study, youth from democratic families gave more favorable responses than youth from authoritarian families. Youth reared in democratic families also had fewer problems than did those reared in authoritarian homes. More high school graduates of 1949 went on to college than during the depression and war years. During all three periods, more youth from metropolitan areas than from rural areas and smaller cities went on to college.

Rural Churches

As a result of research the Pennsylvania station points to improvements that might be made in the programs of rural churches. Many of these churches, particularly in the open country and small villages, did not have such activities as organized groups for men or young people, choirs, "church family nights," lay leadership training classes, financial budgets, annual canvasses of members to support the budget, weekday religious education, and the like. Even such an elementary thing as regular church services at the same hour each Sunday was absent from many of the more rural churches. Churches that had gained membership, in general, had such activities. Also, they had pastors who had prepared themselves at college and seminary, and who were not overloaded by being required to divide their time among several churches.

The importance of the Sunday school to the church was indicated by the fact that nearly half of the new church members came from the Sunday school. In this connection, it is worth noting that in the more rural Sunday schools, there was a tendency to use other than the hymnals and teaching materials published by the denomination with which the church was associated.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

Personnel and Publications

The research personnel of the experiment stations in 1952 included 3,408 staff members devoting full time to station research and 3,868 who divided time between research and teaching or extension work.

The total in both categories, 7,276, represented an increase of 62 over the total of 1951.

Printed publications of the experiment stations in 1952 included 797 bulletins, circulars, and reports; 4,612 articles in scientific journals; and 511 miscellaneous publications. In addition, 617 popular and 749 technical reports, bulletins, and circulars were processed by the stations.

Data by individual States relating to personnel and publications are shown in tables 1 and 2.

Income and Expenditures

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1952 totaled $4,565,000, each State, Hawaii, and Puerto Rico receiving $90,000 and Alaska $65,000. A total of $2,863,708 was appropriated under the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, Alaska, and Puerto Rico as shown in table 3. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944. The total amount of Federal-grant funds appropriated to this Office under the Hatch, Adams, and Purnell Acts, and title I, section 5, of the Bankhead-Jones Act, was $7,428,708.

Under title I, section 9, of the Bankhead-Jones Act $5,000,000 was appropriated. Of this total $150,000, authorized by section 9 (c) of the act, was available to the Office of Experiment Stations for administration. Of the remainder $3,600,000 was allotted to the States, Hawaii, Alaska, and Puerto Rico, under the formulas described in sections 9 (b) (1) and (2); $1,250,000 was available for allotment to the States for cooperative regional research projects authorized by section 9 (b) (3) and for travel by the Committee of Nine established in accordance with this section. The amounts allotted under sections 9 (b) (1), (2), and (3) are shown in table 3. Also shown are the unexpended balances of allotments for fiscal year 1951, which were available for expenditure during fiscal year 1952.

In addition to the Federal-grant funds enumerated above, the Office received funds from title II of the Agricultural Marketing Act for allotment to the State agricultural experiment stations for marketing research. Allotments totaling $241,599.80 were made to the stations during the fiscal year 1952 (table 3).

Non-Federal income of the stations appears in table 4.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in tables 5, 6, 7, 8, 9, and 10; expenditures of non-Federal funds are indicated in table 11. The 1952 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled $56,883,853.97, as compared with $50,972,123.13 in 1951. The 1952 non-Federal fund expenditures by all of the stations approximated $4.42 for each $1 of Federal grants. Summaries of expenditures appear in tables 12 and 13.

Expenditures and allotments of funds from title II of the Agricultural Marketing Act are shown in table 14.

TABLE 1.—*Organization and personnel of the experiment stations for the year ended June 30, 1952*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel				
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers
			Number	*Number*	*Number*	*Number*	*Number*
Alabama	Feb. 27, 1889	Apr. 1, 1888	64	60	1	2	127
Alaska	May 2, 1929	May 1, 1931	24				24
Arizona	Mar. 19, 1889	July 1, 1889	29	42			71
Arkansas	Mar. 7, 1889	Apr. 2, 1888	35	52	1	1	89
California	Mar. 12, 1889	Mar. 13, 1888	121	332			453
Colorado	Mar. 25, 1889	Feb. 20, 1888	46	80		3	129
Connecticut:							
State	May 18, 1887	May 18, 1887	74				74
Storrs	do	Apr. 1, 1888	35	28	4	6	73
Delaware	Apr. 14, 1887	Feb. 21, 1888	15	16	6	4	41
Florida	June 7, 1887	Mar. 16, 1888	153	21	8	5	187
Georgia	Dec. 24, 1888	Feb. 18, 1888	130	49	1	12	192
Hawaii	Mar. 31, 1911	July 1, 1929	44	16	2	1	63
Idaho	Jan. 23, 1891	Feb. 26, 1892	31	41		1	73
Illinois	May 11, 1887	Mar. 21, 1888	92	111	13	6	222
Indiana	Jan. 19, 1889	July 1, 1887	105	92	17	12	226
Iowa	Mar. 1, 1888	Feb. 17, 1888	67	132	29	15	243
Kansas	Mar. 3, 1887	Feb. 8, 1888	43	172	1	1	217
Kentucky	Feb. 20, 1888	Apr. 29, 1888	106	30	6	12	154
Louisiana	July 12, 1888	Apr. 5, 1887	117	54	1		172
Maine	Mar. 16, 1887	Feb. 16, 1888	31	28	2	1	62
Maryland	Mar. 6, 1888	Mar. 9, 1888	20	27	8	32	87
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	82	16			98
Michigan	Apr. 12, 1889	Feb. 26, 1888	86	117	10	8	221
Minnesota	Feb. 4, 1889	Jan. 26, 1888	34	157	5	4	200
Mississippi	Jan. 31, 1888	Spring, 1888	85	43		3	131
Missouri	June 11, 1889	Jan. 31, 1888	24	127	2	3	156
Montana	Feb. 16, 1893	July 1, 1893	49	55	1	13	118
Nebraska	Mar. 31, 1887	June 14, 1887	69	72		1	142
Nevada	Feb. 8, 1889	Dec. —, 1887	16			2	18
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	18	43	3	5	69

New Jersey	Mar. 16, 1887	Mar. 5, 1888	71	71	2	2	6
New Mexico	Feb. 28, 1889	Nov. 14, 1889	31	30	1	2	14
New York:							64
Cornell	Mar. 30, 1887	Apr. 30, 1888	39	150	14	30	233
State	(1)		71				71
North Carolina	Mar. 7, 1887	Dec. 5, 1889	109	98		4	211
North Dakota	Mar. 8, 1890	Oct. 15, 1890	42	34			76
Ohio	Mar. 16, 1887	Apr. 2, 1888	91	68			159
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	78	100	3		181
Oregon	Feb. 25, 1889	July 2, 1888	136	83	1	3	223
Pennsylvania	June 3, 1887	June 30, 1887		211			211
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	81				81
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	19	15	2	5	41
South Carolina	Dec. 22, 1887	Jan. —, 1888	93	25	2	1	121
South Dakota	Mar. 11, 1887	Nov. 17, 1887	43	50		1	94
Tennessee	Mar. 29, 1887	July 24, 1887	100	41		8	149
Texas	Apr. 2, 1887	Jan. 25, 1888	171	65	4	15	255
Utah	Mar. 8, 1888	Nov. 6, 1889	45	48	1	4	98
Vermont	Nov. —, 1888	Feb. 28, 1888	9	25	5	12	51
Virginia	Feb. 29, 1888	June 13, 1888	101	27	3	6	137
Washington	Mar. 9, 1891	May 1, 1891	103	74			177
West Virginia	Feb. 22, 1889	June 11, 1888	15	54	1	3	73
Wisconsin	(2)	July 1, 1887	87	113	3	23	226
Wyoming	Jan. 10, 1891	Mar. 27, 1891	28	37		1	66
Total			3,408	3,432	163	273	7,276

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
[2] Session of 1887.

TABLE 2.—*Publications issued by the agricultural experiment stations during the fiscal year ended June 30, 1952*

Station	Printed publications																Processed publications			
	Reports, bulletins, and circulars				Articles in journals				Periodicals				Pamphlets, leaflets, etc.				Reports, bulletins, circulars, etc.			
	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies reprinted	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies	Pop.	Tech.	Pages	Copies
Alabama	8	3	462	57,500	----	61	266	3,200	----	----	----	----	2	----	12	11,000	9	----	236	46,150
Alaska	2	3	121	7,500	7	3	27	----	----	----	----	----	1	----	2	2,000	2	5	186	1,860
Arizona	11	4	414	34,000	----	30	150	----	4	----	48	36,500	----	1	16	1,000	6	----	165	1,750
Arkansas	----	14	548	54,000	----	13	41	----	----	2	16	11,000	----	8	214	32,500	----	4	38	4,550
California	10	10	1,436	260,100	358	549	10,642	----	12	14	580	513,899	----	----	----	----	----	14	530	7,000
Colorado	12	4	1,538	163,141	----	30	480	6,000	2	----	104	151,800	1	----	1	2,000	34	----	670	44,000
Connecticut:																				
State	4	9	658	53,300	38	77	315	----	2	----	16	24,000	1	----	6	12,000	19	1	147	6,162
Storrs	----	15	718	40,000	----	30	299	10,550	----	----	----	----	----	----	----	----	----	13	136	10,950
Delaware	----	2	48	4,000	----	35	140	----	----	26	209	578	----	----	----	----	----	----	----	----
Florida	39	2	1,183	391,000	93	164	626	----	----	----	----	----	----	----	----	----	----	----	----	----
Georgia	7	----	200	46,000	8	54	413	74,000	1	----	16	28,000	----	----	----	----	54	----	388	187,000
Hawaii	6	3	160	20,640	24	----	198	----	1	----	8	2,500	16	----	294	21,425	----	----	----	----
Idaho	6	----	108	34,500	----	20	(1)	----	4	----	32	60,000	----	----	----	----	1	----	42	1,500
Illinois	----	10	432	79,550	----	178	968	----	----	33	196	122,500	----	----	----	----	----	162	1,450	53,400
Indiana	7	19	942	156,000	----	74	516	----	----	4	20	2,600	----	----	----	----	52	18	227	147,250
Iowa	1	7	506	47,100	----	174	1,338	----	12	----	200	248,000	59	----	275	78,000	20	----	163	23,850
Kansas	19	2	622	104,500	56	169	1,883	24,600	----	----	----	----	2	----	16	15,000	84	59	1,236	146,522
Kentucky	4	28	1,119	142,500	----	35	133	----	----	----	----	----	----	----	----	----	1	26	116	19,650
Louisiana	2	10	508	55,500	----	99	450	----	----	1	32	16,800	----	----	----	----	7	91	1,046	47,800
Maine	----	15	380	58,600	59	16	55	----	----	----	----	----	----	4	141	3,350	----	8	98	1,600
Maryland	2	11	352	29,500	----	36	196	----	----	----	----	----	2	----	52	2,500	9	----	199	4,075
Massachusetts	----	16	694	60,500	----	45	246	12,150	1	12	64	10,100	----	----	----	----	----	----	----	----
Michigan	10	9	856	110,150	12	121	444	----	4	----	483	10,000	2	----	95	1,200	----	----	----	----
Minnesota	6	8	490	70,000	----	157	927	----	3	----	48	49,000	2	----	48	16,500	----	19	428	13,950
Mississippi	26	1	644	123,500	----	31	279	----	12	----	96	456,000	12	----	22	20,000	6	----	151	6,500
Missouri	35	24	2,206	244,850	----	53	(1)	----	12	----	72	312,000	52	----	52	104,000	----	----	----	----
Montana	10	----	360	57,000	----	18	95	----	----	----	----	----	----	----	----	----	11	----	455	4,700
Nebraska	10	1	344	50,500	----	28	(1)	----	----	----	----	----	11	----	20	20,000	14	----	165	35,000
Nevada	1	----	61	2,500	----	----	----	----	----	----	----	----	----	----	----	----	2	----	11	5,000
New Hampshire	5	----	189	8,200	----	3	15	700	----	----	----	----	----	----	----	----	----	----	----	----

New Jersey	6	6	316	56,700	------	55	438	----------	1	1	1,024	90,000	11	------	134	11,700	3	------	28	9,500
New Mexico	9	------	232	29,200	------	8	39	1,250	------	------	----------	----------	------	------	----------	----------	17	------	143	17,000
New York:																				
Cornell	------	19	892	99,450	------	617	2,645	----------	4	------	64	97,700	------	------	----------	----------	------	177	3,748	(1)
State	------	6	204	24,400	------	36	(1)	3,200	4	------	64	97,700	------	------	----------	----------	------	----------	----------	----------
North Carolina	6	2	(1)	36,500	------	------	----------	----------	4	------	64	24,000	------	------	----------	----------	------	11	256	10,850
North Dakota	6	2	316	61,500	41	------	192	----------	36	------	289	46,050	------	------	----------	----------	39	2	193	73,805
Ohio	2	22	1,054	113,250	6	------	112	126,000	------	4	18	11,250	------	52	(1)	(1)	----------	----------	----------	----------
Oklahoma	14	4	261	73,250	------	52	174	(1)	6	------	72	18,000	17	------	206	68,750	20	------	171	28,420
Oregon	19	4	808	114,250	------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	17	------	161	34,200
Pennsylvania	22	14	662	136,500	------	62	358	----------	3	------	36	32,000	------	------	----------	----------	------	3	15	1,100
Puerto Rico	------	9	335	30,000	------	10	1,049	30,988	------	------	----------	----------	(1)	(1)	62	(1)	5	2	133	4,000
Rhode Island	1	7	310	19,500	------	9	47	2,400	------	------	----------	----------	------	7	60	12,500	------	8	19	(1)
South Carolina	------	13	782	63,200	11	16	63	1,300	------	------	----------	----------	------	------	----------	----------	19	18	230	6,420
South Dakota	19	3	604	136,000	------	20	147	----------	4	------	104	19,900	3	------	20	1,500	21	------	346	(1)
Tennessee	7	5	368	69,000	10	17	82	----------	2	------	24	6,000	1	------	4	10,000	----------	----------	----------	----------
Texas	16	2	744	105,000	------	105	973	----------	------	------	----------	----------	5	------	72	28,000	100	25	894	357,250
Utah	4	4	314	32,000	3	23	151	----------	1	------	92	26,000	------	------	----------	----------	17	------	204	4,600
Vermont	3	------	172	7,175	4	7	78	----------	------	------	----------	----------	3	------	20	7,000	----------	----------	----------	----------
Virginia	11	2	438	38,000	------	73	281	----------	------	------	----------	----------	------	------	----------	----------	------	35	553	1,500
Washington	------	14	435	36,500	------	109	805	19,825	------	------	----------	----------	------	------	----------	----------	------	46	483	50,850
West Virginia	10	2	316	65,000	------	7	51	1,450	3	------	32	18,000	------	------	----------	----------	3	2	114	13,000
Wisconsin	3	4	292	44,000	------	336	(1)	----------	------	------	----------	----------	------	------	----------	----------	5	------	63	9,000
Wyoming	17	5	682	62,600	------	17	33	(1)	------	------	----------	----------	1	------	8	2,000	20	------	257	11,400
Total	418	379	28,836	4,019,106	730	3,882	28,860	317,613	138	97	4,123	2,541,877	204	72	1,852	483,925	617	749	16,294	1,453,114

[1] Total unknown.

TABLE 3.—*Federal funds available to the experiment stations for the year ended June 30, 1952*

Station	Federal-grant funds							Contractual Federal funds, Agricultural Marketing Act, title II			Total Federal funds available
	Hatch, Adams, and Purnell [2]	Bankhead-Jones, title I					Total				
		Sec. 5	Secs. 9 (b) 1 and 9 (b) 2		Sec. 9 (b) 3						
		1952 appropriation	Carry-over from 1951	1952 appropriation	Carry-over from 1951	1952 appropriation		Carry-over from 1951	1952 allotment	Total	
Alabama	$90,000	$88,305.89	$22,238.63	$114,694.35	$1,736.66	$19,935.00	$336,910.53	$748.59	$2,500.00	$3,248.59	$340,159.12
Alaska	65,000	4,736.40		21,899.00			91,635.40				91,635.40
Arizona	90,000	16,740.68	2,167.87	32,066.37	4,440.16	19,250.00	164,665.08				164,665.08
Arkansas	90,000	66,187.20	14,940.05	94,982.13	753.66	22,400.00	289,263.04				289,263.04
California	90,000	102,716.44		94,748.18	3,533.01	23,489.00	314,486.63	90.52	8,200.00	8,290.52	322,777.15
Colorado	90,000	25,460.16	5,796.66	41,466.00	18,555.89	30,850.00	212,128.71				212,128.71
Connecticut:											
State	45,000	11,257.19	2,991.68	17,176.19	101.72		76,526.78				76,526.78
Storrs	45,000	11,257.19	2,334.75	17,176.19	1,508.62	18,800.00	96,076.75	.42	5,200.00	5,200.42	101,277.17
Delaware	90,000	5,970.02	2,840.25	24,262.03		3,500.00	126,572.30				126,572.30
Florida	90,000	48,046.76	11,139.54	54,413.30	4,688.26	10,900.00	219,187.86	6,041.12	1,500.00	7,541.12	226,728.98
Georgia	90,000	98,402.95	10,533.36	119,528.14	9,093.24	40,700.00	368,257.69	5,058.21	16,100.00	21,158.21	389,415.90
Hawaii	90,000	10,463.17	9,363.56	28,510.38		5,000.00	143,367.11	6,979.81	3,000.00	9,979.81	153,346.92
Idaho	90,000	16,866.19	5,048.42	35,733.29	69.37	16,300.00	164,017.27				164,017.27
Illinois	90,000	99,478.95	15,860.72	105,191.13	11,253.45	17,320.00	339,104.25	4,007.57	7,100.00	11,107.57	350,211.82
Indiana	90,000	79,141.32	5,010.50	89,779.81	5,931.17	45,729.68	315,592.48	3,740.54	26,000.00	29,740.54	345,333.02
Iowa	90,000	74,227.20		89,613.46	2,497.96	61,520.00	317,888.62	291.67	21,800.00	22,091.67	339,980.29
Kansas	90,000	53,057.23	182.42	65,710.25	.23	26,070.32	235,020.45	1.10	10,000.00	10,001.10	245,021.55
Kentucky	90,000	93,378.88	3,394.46	114,595.55	52.80	8,600.00	310,021.69				310,021.69
Louisiana	90,000	60,813.78	9,147.30	82,807.72	4,025.16	21,700.00	268,493.96				268,493.96
Maine	90,000	22,270.68	58.84	37,118.51		28,400.00	177,848.03		7,500.00	7,500.00	185,348.03
Maryland	90,000	36,488.62	6,224.29	46,606.00	1,067.56	17,715.00	198,101.47	1,095.38	6,500.00	7,595.38	205,696.85
Massachusetts	90,000	36,698.19		42,673.96	1,069.25	10,500.00	180,941.40				180,941.40
Michigan	90,000	93,777.64	9,856.64	98,803.62	8,940.86	18,000.00	319,378.76	24,261.61	21,460.00	45,721.61	365,100.37
Minnesota	90,000	68,128.03	22,755.17	88,687.34	5,791.03	38,140.00	313,501.57				313,501.57
Mississippi	90,000	80,016.75	7,981.16	113,680.68	7,268.20	37,905.00	336,851.79	14,365.78	21,900.00	36,265.78	373,117.57
Missouri	90,000	78,849.57		101,148.44		23,350.00	293,348.01		6,000.00	6,000.00	299,348.01
Montana	90,000	18,004.00	1,015.10	34,574.90	2,922.68	37,570.00	184,086.68				184,086.68
Nebraska	90,000	41,343.56	2,920.25	56,401.18	118.16	20,500.00	211,283.15	1,276.91		1,276.91	212,560.06
Nevada	90,000	3,435.49		21,852.37		8,400.00	123,687.86				123,687.86
New Hampshire	90,000	11,363.43		27,769.68		6,400.00	135,533.11				135,533.11

New Jersey	90,000	32,575.43	1,244.36	40,589.64	5,878.56	22,765.00	193,052.99	5,957.20	4,200.00	10,157.20	203,210.19
New Mexico	90,000	17,027.28	3,240.94	34,815.85	8.93	20,600.00	165,693.00				165,693.00
New York:											
Cornell	81,000	97,003.93	15,137.98	89,602.12	10,613.09	48,865.00	342,222.12	1,788.44	4,400.00	6,188.44	348,410.56
State	9,000	10,778.21	1,881.40	9,955.79			31,615.40	199.27	10,000.00	10,199.27	41,814.67
North Carolina	90,000	135,186.64	3,896.78	150,320.28	6,033.83	35,100.00	420,537.53	62.93	3,600.00	3,662.93	424,200.46
North Dakota	90,000	26,670.28	6,788.92	43,632.58	932.31	4,550.00	172,574.09				172,574.09
Ohio	90,000	118,853.05	55,357.07	119,364.53	544.65	18,900.00	403,019.30		10,000.00	10,000.00	413,019.30
Oklahoma	90,000	63,847.68	5,956.22	83,190.29	7,977.48	14,350.00	265,321.67				265,321.67
Oregon	90,000	35,230.21	3,087.71	46,559.28	5,833.40	37,450.00	218,160.60	2.13	2,000.00	2,002.13	220,162.73
Pennsylvania	90,000	155,317.78	14,076.82	129,176.06	14,706.73	24,090.00	427,367.39				427,367.39
Puerto Rico	90,000	66,036.41	13,140.66	94,119.65		3,500.00	266,796.72	5,541.21	5,900.00	11,441.21	278,237.93
Rhode Island	90,000	6,257.12	4,360.69	23,221.61	1,196.57	26,335.00	151,370.99				151,370.99
South Carolina	90,000	68,111.24	7,581.51	88,339.12	2,030.01	29,829.00	285,890.88				285,890.88
South Dakota	90,000	26,510.78	9,814.37	42,350.30	2,196.62	15,600.00	186,472.07				186,472.07
Tennessee	90,000	92,293.90	3,473.18	114,687.23	2,160.74	28,565.00	331,180.05	7,940.35	2,400.00	10,340.35	341,520.40
Texas	90,000	150,461.58	4,450.59	174,973.43	890.45	64,341.00	485,117.05	1,132.85	19,339.80	20,472.65	505,589.70
Utah	90,000	12,499.09	808.56	29,461.84	21,138.02	32,151.00	186,058.51				186,058.51
Vermont	90,000	12,881.06	4,967.17	29,564.84	302.52	7,115.00	144,833.59				144,833.59
Virginia	90,000	88,612.55	11,803.22	100,971.80	3,000.00	21,525.00	315,912.57				315,912.57
Washington	90,000	43,950.86	19,456.64	53,951.33	8,899.50	56,140.00	272,398.33	1,887.13	5,700.00	7,587.13	279,985.46
West Virginia	90,000	65,794.28	27,399.20	71,963.07	5,719.53	31,015.00	291,891.08		1,800.00	1,800.00	293,691.08
Wisconsin	90,000	73,259.15	6.15	89,466.98	19,172.08	47,420.00	319,324.36	8,188.66	7,500.00	15,688.66	335,013.02
Wyoming	90,000	7,662.93	5,374.15	25,992.07	3,160.97	15,150.00	147,340.12				147,340.12
Total	4,565,000	2,863,708.00	397,105.91	3,599,999.84	217,815.09	1,244,300.00	12,887,928.84	100,659.40	241,599.80	342,259.20	13,230,188.04

[1] Includes unexpended balances from the previous year as follows:
Hatch—Storrs (Connecticut), $0.06; Delaware, $175.07; Maryland, $1.26; Cornell (New York), $0.52; New York (State), $0.02.
Adams—Delaware, $152.08.
Purnell—Storrs (Connecticut), $0.79; Delaware, $5.54; Cornell (New York), $0.16.
Bankhead-Jones, Section 5—Connecticut, $48.24; Storrs (Connecticut), $0.66; Cornell (New York), $0.54; New York (State), $30.73; Washington, $123.87.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico. Adams, $15,000 for each State, Alaska, Hawaii, and Puerto Rico. Purnell, $60,000 for each State, Hawaii, and Puerto Rico; $35,000 for Alaska.

TABLE 4.—*Non-Federal funds available to the experiment stations for the year ended June 30, 1952*

Station	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total
Alabama	$673,385.00	$88,696.43		$584,199.92		$286,301.31	$1,632,582.66
Alaska	136,050.00			54,802.66		27,959.68	218,812.34
Arizona	333,626.41	44,292.93		44,937.83			422,857.17
Arkansas	361,236.45	45,969.60		207,097.15		103,989.06	718,292.26
California	4,946,535.81	273,939.46		57,490.16		336,605.00	5,614,570.43
Colorado	316,073.19	171,895.42		119,448.08	$7,434.38	136,102.03	750,953.10
Connecticut:							
State	370,840.22	17,220.00					388,060.22
Storrs	274,153.98	98,027.28					372,181.26
Delaware	141,417.21			121,273.11	37,559.42	34,833.14	335,082.88
Florida	2,307,021.00	195,422.30		554,221.63		353,190.23	3,409,855.16
Georgia	362,178.00	43,285.24		190,252.15		97,251.13	692,966.52
Hawaii	416,424.67	13,447.95		57,994.80	8,000.00	5,020.30	500,887.72
Idaho	505,375.99	12,815.00		129,903.32		70,224.19	718,318.50
Illinois	1,510,468.68	209,057.46		368,513.31			2,088,039.45
Indiana	979,042.50	224,180.78	$232,521.83	633,925.18	219,882.66	515,261.83	2,804,814.78
Iowa	1,080,000.00	551,032.47		601,671.38		212,598.07	2,445,301.92
Kansas	805,570.00			318,778.50		170,527.56	1,294,876.06
Kentucky	257,021.68		240,213.33	93,989.89	53,009.14		644,234.04
Louisiana	1,297,464.59	29,856.33			75,789.18		1,403,110.10
Maine	215,707.00	14,514.54		30,000.00		34,732.52	294,954.06
Maryland	330,932.27	73,458.17		130,885.93		104,984.92	640,261.29
Massachusetts	442,213.45	47,778.17				21,178.65	511,170.27
Michigan	1,048,245.49	273,536.78				121,641.32	1,443,423.59
Minnesota	1,412,843.83	192,397.32	9,273.83	440,651.62			2,055,166.60
Mississippi	673,916.70	66,744.73		490,717.46	48,849.27	232,015.21	1,512,243.37
Missouri	238,041.61	335,219.35	217,214.79	166,245.65		259,218.28	1,215,939.68
Montana	458,300.87	16,520.00		345,810.70		179,099.07	999,730.64
Nebraska	567,685.44			605,716.73		62,277.02	1,235,679.19
Nevada	36,756.99			35,079.49		37,213.90	109,050.38
New Hampshire	59,512.56			6,381.97		739.65	66,634.18
New Jersey	863,897.69	405,403.71				9,523.72	1,278,825.12
New Mexico	290,950.00	8,256.38		56,625.08	1,000.00	78,782.93	435,614.39
New York:							
Cornell	2,342,887.54			422,321.68	6,752.13		2,771,961.35
State	870,044.98			23,572.69			893,617.67
North Carolina	1,168,731.51			170,356.64	70,994.15		1,410,082.30

North Dakota	496,733.94	39,492.96		157,333.90		86,043.28	779,604.08
Ohio	1,211,844.12			242,766.83		411,992.55	1,866,603.50
Oklahoma	847,394.00	31,945.81		430,156.05	10,860.37	108,126.71	1,428,482.94
Oregon	1,272,748.40	141,658.76	221,114.78	190,983.21			1,826,505.15
Pennsylvania	706,047.00	165,260.60		149,280.41	68,106.33	86,433.27	1,175,127.61
Puerto Rico	673,989.00				197,789.00	151,405.00	1,023,183.00
Rhode Island	60,208.07	17,748.36		21,599.72		23,629.51	123,185.66
South Carolina	449,394.80	19,650.00		260,036.74		35,775.76	764,857.30
South Dakota	269,073.00	11,384.68		160,608.71		38,877.30	479,943.69
Tennessee	310,057.12	82,752.28		219,320.39			612,129.79
Texas	1,230,010.00	214,011.73	69,811.37	1,001,755.89	112,105.63	756,668.05	3,384,362.67
Utah	356,000.00	123,715.10		76,615.98	1,326.90	124,398.01	682,055.99
Vermont	75,173.80			2,808.99	19,057.19	14,956.78	111,996.76
Virginia	806,552.74			92,634.12		86,182.95	985,369.81
Washington	1,501,279.41	150,649.66		206,695.46			1,858,624.53
West Virginia	227,812.00	15,813.73		176,527.18	1,045.00	109,637.63	530,835.54
Wisconsin	1,448,547.00	557,683.00		527,926.00			2,534,156.00
Wyoming	308,623.36	15,811.45		105,869.51		72,629.07	502,933.39
Total	40,346,041.07	5,040,545.92	990,149.93	11,085,783.80	939,560.75	5,598,026.59	64,000,108.06

TABLE 5.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)* [1] *for the year ended June 30, 1952*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$13,958.28	$139.06	$76.22	$29.30	$76.45		$4.50	$584.79	$131.40				$15,000.00		$15,000
Alaska	13,623.03	346.86	12.68				18.00	896.92	102.51				15,000.00		15,000
Arizona	14,932.25			.43				18.57	48.75				15,000.00		15,000
Arkansas	11,244.13	520.62			70.00	$1,486.29	176.00	1,178.01	84.95		$240.00		15,000.00		15,000
California	15,000.00												15,000.00		15,000
Colorado	11,877.82	1,400.66	1.20	26.40		109.75	51.20	360.79	737.12		435.06		15,000.00		15,000
Connecticut:															
State						5,233.71	375.00	1,891.29					7,500.00		7,500
Storrs	4,426.13	414.07		.10		854.08		8.60	1,339.61				7,042.59	$457.41	7,500
Delaware	11,961.81	333.24	8.62	2,497.23		42.25	14.10	29.31	113.37				14,999.93	.07	15,000
Florida	15,000.00												15,000.00		15,000
Georgia	10,006.95		2.19			559.14	38.12	2,565.69	1,827.91				15,000.00		15,000
Hawaii	14,512.52						6.78		480.70				15,000.00		15,000
Idaho	10,486.80	2,114.35	6.88	79.74	42.25	1,776.40	38.40	429.53	25.65				15,000.00		15,000
Illinois	14,000.85					300.00					699.15		15,000.00		15,000
Indiana	15,000.00												15,000.00		15,000
Iowa	14,006.64		23.10	6.90		910.33		53.03					15,000.00		15,000
Kansas	14,269.82	207.82		36.39	36.20	27.15	33.18	215.23	33.56			$140.65	15,000.00		15,000
Kentucky	14,192.00	142.39				558.57						107.04	15,000.00		15,000
Louisiana	11,874.47	30.06				265.24	617.43	185.94	2,026.86				15,000.00		15,000
Maine	11,540.22	257.07	33.43	38.85	558.68	177.48	6.60	1,828.88	558.79				15,000.00		15,000
Maryland	6,650.00	4,344.46				1,570.32		1,742.50	692.72				15,000.00		15,000
Massachusetts	8,186.85		7.95				305.00	2,090.15	4,410.05				15,000.00		15,000
Michigan	7,500.00					7,500.00							15,000.00		15,000
Minnesota	11,457.08	433.49				445.57	109.65	1,204.97	1,135.35		213.89		15,000.00		15,000
Mississippi	13,280.92	10.90	2.16	184.42	113.81	62.00	40.74	1,127.85	177.20				15,000.00		15,000
Missouri	12,884.26	141.69	44.61				119.57	637.71	821.96	$252.00		98.20	15,000.00		15,000
Montana	13,228.80	618.02		3.78		604.10		373.60	171.70				15,000.00		15,000
Nebraska	15,000.00												15,000.00		15,000
Nevada	10,201.53	349.51	3.27	650.41	152.66	635.60	31.75	2,806.57	168.70				15,000.00		15,000
New Hampshire	13,044.66	23.55		581.35	1,100.00		88.86	148.08	13.50				15,000.00		15,000

New Jersey	11,991.10	337.54		10.00			417.89	484.43	1,759.04				15,000.00		15,000
New Mexico	13,367.24	363.96	7.50	28.65	294.87		302.56	307.33	327.89				15,000.00		15,000
New York:															
Cornell	12,436.62	1.35			132.13			845.18	78.30				13,493.58	6.42	13,500
State	1,022.13								477.27				1,499.40	.60	1,500
North Carolina	13,615.45	172.09		3.80		169.00	136.12	721.70	181.84				15,000.00		15,000
North Dakota	14,239.58							74.17			686.25		15,000.00		15,000
Ohio	12,580.80	1,116.28	24.40					199.73	1,078.79				15,000.00		15,000
Oklahoma	10,172.60	125.61				1.35	354.79	3,177.75	855.64	312.26			15,000.00		15,000
Oregon	13,200.00	1,800.00											15,000.00		15,000
Pennsylvania	8,890.55	229.82				5,428.74		351.20	99.69				15,000.00		15,000
Puerto Rico	14,022.42	572.48		7.60				154.50	243.00				15,000.00		15,000
Rhode Island	10,981.45	363.50		448.17		1,772.23	320.11	1,114.54					15,000.00		15,000
South Carolina	11,979.97			75.76		298.50	94.48	723.29	1,828.00				15,000.00		15,000
South Dakota	7,589.28	736.65	18.81	17.10	3.00	3,882.23	153.77	2,026.33	572.83				15,000.00		15,000
Tennessee	14,812.95					187.05							15,000.00		15,000
Texas	11,189.97	1,674.67		276.11		316.05	22.45	858.95	661.80				15,000.00		15,000
Utah	13,746.00	25.86				1,209.08		19.06					15,000.00		15,000
Vermont	12,363.24	532.94		695.59		199.81	669.84	70.22	275.41		141.24	51.71	15,000.00		15,000
Virginia	14,951.33							48.67					15,000.00		15,000
Washington	13,467.62	3.89	11.32				157.48	570.07	789.62				15,000.00		15,000
West Virginia	8,700.00	473.90			354.11	2,909.21	8.40	2,551.83					14,997.45	2.55	15,000
Wisconsin	5,188.00	597.93					175.00	8,560.19	478.88				15,000.00		15,000
Wyoming	12,973.31		56.29	23.25		1,407.72	13.47	525.96					15,000.00		15,000
Total	616,829.43	20,956.29	340.63	5,721.33	2,934.16	40,898.95	4,901.24	43,763.11	24,810.36	564.26	2,415.59	397.60	764,532.95	467.05	765,000

[1] Extended to Hawaii by act of May 16, 1928, to Alaska by act of Feb. 23, 1929, and to Puerto Rico by act of Mar. 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)* [1] *for the year ended June 30, 1952*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$11,738.33	$382.88	$16.75	$33.50	$525.00	$167.83	$992.43	$741.98	$401.30			$15,000.00		$15,000
Alaska	14,750.00	66.80					160.52	22.68				15,000.00		15,000
Arizona	11,769.02	1,398.45	210.83	71.21	32.50	399.11	852.88	266.00				15,000.00		15,000
Arkansas	11,784.14	179.81			142.50	54.83	1,694.23	719.49		$425.00		15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	13,051.04	42.05	100.00	12.50	284.51	226.87	632.23	166.07		484.73		15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	7,500.00											7,500.00		7,500
Delaware	11,924.90	202.19	9.01	9.13		198.18	1,141.40	1,515.19				15,000.00		15,000
Florida	15,000.00											15,000.00		15,000
Georgia	13,256.92	104.47	11.88			49.30	1,577.43					15,000.00		15,000
Hawaii	14,884.00							116.00				15,000.00		15,000
Idaho	13,574.15	447.71	7.88			28.25	942.01					15,000.00		15,000
Illinois	13,727.27					53.21	606.08	41.79		571.65		15,000.00		15,000
Indiana	13,819.56		2.00				1,178.44					15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	11,336.81		5.80			44.60	2,978.52	523.49			$110.78	15,000.00		15,000
Kentucky	14,817.28										182.72	15,000.00		15,000
Louisiana	12,545.44	310.68	5.77	3.85		101.51	1,908.45	124.30				15,000.00		15,000
Maine	13,452.28	35.59				51.05	1,037.68	423.40				15,000.00		15,000
Maryland	11,800.00	124.15	1.56	7.66		378.97	1,913.31	448.50	325.85			15,000.00		15,000
Massachusetts	15,000.00											15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	14,282.78						407.12			310.10		15,000.00		15,000
Mississippi	12,032.21	125.45	5.17	67.62	328.99	601.07	1,659.49		180.00			15,000.00		15,000
Missouri	11,215.31	64.88	55.33		10.80	784.24	2,025.71	268.54			75.19	15,000.00		15,000
Montana	13,536.89	538.81	2.09			86.05	104.27	731.89				15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	12,292.19	108.22	11.53	65.15	24.30	94.25	1,952.28	452.08				15,000.00		15,000
New Hampshire	14,329.06	55.68	6.92	61.40		20.00	467.33	59.61				15,000.00		15,000

New Jersey	13,375.40	69.07		2.08		182.38	920.15	450.92				15,000.00		15,000
New Mexico	13,683.46		5.37	6.60	197.41	322.26	508.60	276.30				15,000.00		15,000
New York:														
Cornell	7,765.53	21.52				390.54	3,035.75	2,286.66				13,500.00		13,500
State							42.64	1,453.00				1,495.64	$4.36	1,500
North Carolina	14,314.87						62.35	622.78				15,000.00		15,000
North Dakota	14,297.88	1.64	5.72	62.25		1.50	95.01	45.00		491.00		15,000.00		15,000
Ohio	14,246.38						495.47	258.15				15,000.00		15,000
Oklahoma	10,842.13	317.27				429.25	2,164.75	1,246.60				15,000.00		15,000
Oregon	15,000.00											15,000.00		15,000
Pennsylvania	13,826.39		28.22			12.44	1,072.51	60.44				15,000.00		15,000
Puerto Rico	11,196.78	351.78	10.50			379.57	594.98	2,466.39				15,000.00		15,000
Rhode Island	14,326.04	102.04	4.26				533.98	24.50				14,990.82	9.18	15,000
South Carolina	14,020.50	185.50		50.36	15.98		514.70	212.96				15,000.00		15,000
South Dakota	12,288.84	610.50	6.85	3.25		103.76	1,031.06	955.74				15,000.00		15,000
Tennessee	14,009.82			12.71	12.45	213.01	741.77	10.24				15,000.00		15,000
Texas	12,980.15	104.15	7.00	11.97		964.46	168.08	394.30	369.89			15,000.00		15,000
Utah	14,932.55							67.45				15,000.00		15,000
Vermont	12,477.70	9.12	32.05	4.93		138.63	650.48	1,198.30	54.55	397.80	36.44	15,000.00		15,000
Virginia	14,689.91	161.40				80.00	68.69					15,000.00		15,000
Washington	11,176.35	210.30	41.21			65.94	1,055.11	2,450.32				14,999.23	.77	15,000
West Virginia	11,242.40	13.72				5.10	1,826.77	1,912.01				15,000.00		15,000
Wisconsin	13,636.23						1,363.77					15,000.00		15,000
Wyoming	14,420.00	189.00						391.00				15,000.00		15,000
Total	679,668.89	6,534.83	593.70	486.17	1,574.44	6,628.16	41,678.43	23,404.07	1,331.59	2,680.28	405.13	764,985.69	14.31	765,000

[1] Extended to Hawaii by act of May 16, 1928, to Puerto Rico by act of Mar. 4, 1931, and to Alaska by act of June 30, 1936.

TABLE 7.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)* [1] *for the year ended June 30, 1952*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication services	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$43,948.38	$1,319.47	$19.68	$123.28	$1,352.60	$1,451.62	$459.40	$4,915.07	$6,410.50				$60,000.00		$60,000
Alaska	33,020.92	318.23					100.00	1,092.08	250.72	$218.05			35,000.00		35,000
Arizona	41,518.58	3,912.88	296.11	125.98		743.30	1,271.35	9,512.14	2,619.66				60,000.00		60,000
Arkansas	47,163.58	1,206.92			944.10	655.86	2,251.32	4,257.59	2,521.88		$998.75		60,000.00		60,000
California	60,000.00												60,000.00		60,000
Colorado	46,406.80	2,334.83	8.90	140.74	366.22	100.38	787.55	5,770.59	2,124.79		1,959.20		60,000.00		60,000
Connecticut:															
State	23,902.50	32.60				629.55	1,212.43	652.55	3,150.16	324.71			29,904.50	$95.50	30,000
Storrs	27,592.09	991.73	.59			41.10	79.07	267.09	1,028.29				29,999.96	.04	30,000
Delaware	49,783.33	2,677.41	47.36	.85	79.77	152.09	667.41	4,507.79	2,083.99				60,000.00		60,000
Florida	60,000.00												60,000.00		60,000
Georgia	52,119.74	1,472.56	35.13			16.98	312.12	4,245.73	1,797.74				60,000.00		60,000
Hawaii	51,831.97					252.47	1,481.84	831.44	3,102.28	2,500.00			60,000.00		60,000
Idaho	48,910.49	1,830.23	59.09	41.85		85.71	246.56	8,131.12	623.95	71.00			60,000.00		60,000
Illinois	52,093.21	911.37				435.92	581.60	2,778.28	1,501.89		1,697.73		60,000.00		60,000
Indiana	57,025.50	730.59		180.91			167.73	1,580.21	315.06				60,000.00		60,000
Iowa	60,000.00												60,000.00		60,000
Kansas	54,692.23	805.38	4.85	64.28	7.50	140.62	853.97	2,396.82	432.58			$601.77	60,000.00		60,000
Kentucky	54,700.46	2,041.28	39.38	49.15		1,569.54	140.90	887.98	41.20			530.11	60,000.00		60,000
Louisiana	47,281.69	2,979.95	93.43	32.02	389.82	912.97	1,681.91	4,119.22	2,333.20	175.79			60,000.00		60,000
Maine	46,997.54	2,184.20	44.91	37.78	1,179.48		234.94	6,485.01	2,836.14				60,000.00		60,000
Maryland	49,225.46	385.45	5.09	71.72	61.10	3.25	927.68	6,878.80	2,219.27	222.18			60,000.00		60,000
Massachusetts	48,943.09	1,154.46	46.95				69.28	4,680.04	5,106.18				60,000.00		60,000
Michigan	60,000.00												60,000.00		60,000
Minnesota	51,875.77	1,555.24	126.87	239.42		650.47	382.71	2,379.78	2,081.68		708.06		60,000.00		60,000
Mississippi	49,017.73	1,360.67	37.03	280.46	2,360.55	87.07	883.79	4,937.79	1,034.91				60,000.00		60,000
Missouri	47,700.22	1,403.06	165.37	92.47	143.19	78.80	1,169.48	7,547.99	1,355.14			344.28	60,000.00		60,000
Montana	53,236.18	773.53	27.03	82.17	69.78	2,015.34	218.07	1,912.87	1,665.03				60,000.00		60,000
Nebraska	59,914.79							85.21					60,000.00		60,000
Nevada	43,325.61	311.25	73.20	342.58	2,109.62		918.78	12,225.78	473.68	219.50			60,000.00		60,000
New Hampshire	52,290.60	1,091.54	72.88	18.00	198.00	7.20	218.37	3,990.90	2,112.51				60,000.00		60,000

New Jersey	50,692.60	1,143.51	166.88	4.70	278.00	16.55	568.33	5,533.33	1,596.10				60,000.00		60,000
New Mexico	48,805.29	1,857.32	109.18	126.67	1,673.81		1,297.77	5,148.69	981.27				60,000.00		60,000
New York:															
Cornell	45,824.98	1,091.86	26.47	8.48	418.00	204.80	1,448.19	2,663.63	2,209.12				53,895.53	104.47	54,000
State	4,717.43						236.47	245.94	799.30				5,999.14	.86	6,000
North Carolina	48,959.19	1,728.04		62.78		25.00	416.53	3,838.90	4,969.56				60,000.00		60,000
North Dakota	54,978.87	1,051.14	42.67	48.55	146.84	888.26	156.40	286.04	135.60	73.63	2,192.00		60,000.00		60,000
Ohio	53,922.87	1,881.31	6.87		51.29	41.60	92.32	2,700.28	1,286.96	16.50			60,000.00		60,000
Oklahoma	40,586.00	399.86	141.20			1.50	2,120.42	12,997.73	3,753.29				60,000.00		60,000
Oregon	56,945.14	1,142.29	2.66	38.65		23.46	192.25	356.29	1,299.26				60,000.00		60,000
Pennsylvania	41,906.35	867.09	9.91			902.58	46.16	11,856.05	683.78	3,728.08			60,000.00		60,000
Puerto Rico	45,195.20	4,179.54				2,151.71	297.51	3,760.05	3,952.74				59,536.75	463.25	60,000
Rhode Island	49,839.96	514.40	14.58		12.00	1,897.40	61.84	6,918.49	741.33				60,000.00		60,000
South Carolina	54,303.04	431.55		180.02	163.31	732.26	1,055.22	2,597.24	537.36				60,000.00		60,000
South Dakota	36,718.97	1,241.24	203.53	40.71	12.55	3,247.62	1,362.26	9,837.37	2,335.75	5,000.00			60,000.00		60,000
Tennessee	57,407.90	9.24	7.11		13.62		143.84	1,488.28	820.97	109.04			60,000.00		60,000
Texas	45,622.62	597.63	11.85	126.30	199.80	1,486.67	4,558.79	3,778.30	2,795.45	822.59			60,000.00		60,000
Utah	56,456.06	635.48	12.92				210.50	462.50	2,222.54				60,000.00		60,000
Vermont	44,711.97	2,564.07	50.09	55.69	153.48	2,251.83	1,066.42	3,617.50	2,990.61	1,136.61	1,173.76	227.97	60,000.00		60,000
Virginia	56,854.13	1,200.79	3.39	35.72			200.47	1,368.32	337.18				60,000.00		60,000
Washington	51,744.14	1,312.54	105.00	2.05		11.58	444.28	2,678.92	3,701.49				60,000.00		60,000
West Virginia	49,427.50	349.53	2.50				323.44	6,191.35	3,705.68				60,000.00		60,000
Wisconsin	59,603.52	36.08						250.00	110.40				60,000.00		60,000
Wyoming	59,341.33							293.67	365.00				60,000.00		60,000
Total	2,589,083.52	58,019.34	2,120.66	2,653.98	12,384.43	23,913.06	33,617.67	195,938.74	91,553.17	14,617.68	8,729.50	1,704.13	3,034,335.88	664.12	3,035,000

[1] Extended to Hawaii by act of May 16, 1928, to Alaska by act of Feb. 23, 1929, and to Puerto Rico by act of Mar. 4, 1931.

TABLE 8.—*Expenditures and appropriations under the Bankhead-Jones Act, title I, sec. 5 for the year ended June 30, 1952*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$71,960.65	$1,612.68	$59.84	$140.43	$937.98		$442.41	$11,432.34	$1,719.56				$88,305.89		$88,305.89
Alaska	4,000.00	7.00					9.50	234.05	485.85				4,736.40		4,736.40
Arizona	11,803.54	2,630.86	17.66	68.46			131.26	1,567.72	521.18				16,740.68		16,740.68
Arkansas	53,513.62	1,692.89			966.11	$2,613.31	193.52	4,866.25	841.50		$1,500.00		66,187.20		66,187.20
California	102,716.44												102,716.44		102,716.44
Colorado	18,159.84	663.65	7.94	50.75	663.48	323.62	76.46	3,489.50	1,285.05		739.87		25,460.16		25,460.16
Connecticut:															
State	7,898.98	125.66	2.73			789.35	248.73	1,122.56	500.73	$568.09			11,256.83	$0.36	11,257.19
Storrs	8,760.00							2,487.85					11,247.85	9.34	11,257.19
Delaware	2,895.00					2.85		3,062.92	9.25				5,970.02		5,970.02
Florida	36,648.83	374.57	124.41				128.08	7,040.26	3,348.80				47,664.81	381.95	48,046.76
Georgia	77,988.50	1,307.37	58.74	49.20			161.03	17,643.82	1,194.29				98,402.95		98,402.95
Hawaii	9,744.30	23.50						100.00	595.37				10,463.17		10,463.17
Idaho	14,716.30	472.10	16.10	1.25	6.00		57.75	466.23	1,084.51	45.95			16,866.19		16,866.19
Illinois	89,129.70	1,811.89	8.36	1.50		36.04	451.98	1,159.28	2,779.16		4,101.04		99,478.95		99,478.95
Indiana	67,249.06	567.40	16.21	26.89			313.98	10,922.08	45.70				79,141.32		79,141.32
Iowa	74,227.20												74,227.20		74,227.20
Kansas	44,283.96	324.55	1.41	1.10	14.50	59.43	1,533.25	5,389.15	969.02			$480.86	53,057.23		53,057.23
Kentucky	79,738.29	1,123.02	42.70	487.85		1,560.10	125.25	6,728.76	2,805.41			767.50	93,378.88		93,378.88
Louisiana	46,030.79	2,302.47	175.24	19.56		984.12	1,637.17	7,774.40	1,890.03				60,813.78		60,813.78
Maine	19,540.67	304.61	15.08	5.70	5.00		170.66	1,654.63	574.33				22,270.68		22,270.68
Maryland	26,244.94	3.35	51.70	41.13	16.17	18.48	990.08	6,622.69	2,500.08				36,488.62		36,488.62
Massachusetts	27,925.48	413.86	4.58					3,025.19	5,329.08				36,698.19		36,698.19
Michigan	89,726.28	22.33	30.26				190.45	3,522.98	285.34				93,777.64		93,777.64
Minnesota	51,656.67	2,018.82	222.05	127.65	32.00	188.04	1,155.97	6,396.04	4,284.88	1,580.00	465.09		68,127.21	.82	68,128.03
Mississippi	66,401.13	1,472.63	76.53	359.45	1,640.77	35.56	1,407.31	7,093.21	1,175.16	355.00			80,016.75		80,016.75
Missouri	54,506.17	624.82	121.67	287.74	850.52	36.24	3,712.55	15,198.99	2,936.38	137.42		437.07	78,849.57		78,849.57
Montana	17,042.23	109.77	11.00	36.10			29.66	775.24					18,004.00		18,004.00
Nebraska	41,163.15	7.32						44.69	128.40				41,343.56		41,343.56
Nevada	2,976.89	124.75	3.82				3.00	63.54	263.49				3,435.49		3,435.49
New Hampshire	9,607.07	67.08	9.08	10.55		1.25		540.21	1,128.19				11,363.43		11,363.43

New Jersey	26,068.66	540.73	22.18	----------	192.00	31.51	352.79	4,047.92	1,319.64	----------	----------	----------	32,575.43	----------	32,575.43
New Mexico	12,065.28	52.32	72.80	2.75	30.75	----------	162.48	3,631.95	1,008.95	----------	----------	----------	17,027.28	----------	17,027.28
New York:															
Cornell	68,887.25	1,459.56	60.55	2.70	338.99	139.57	3,052.00	16,580.57	6,481.91	----------	----------	----------	97,003.10	.83	97,003.93
State	10,439.35	----------	----------	----------	----------	----------	----------	80.98	257.73	----------	----------	----------	10,778.06	.15	10,778.21
North Carolina	111,216.74	2,749.58	105.98	311.35	108.93	49.28	7,135.80	8,247.50	5,261.48	----------	----------	----------	135,186.64	----------	135,186.64
North Dakota	25,044.63	203.28	12.13	58.82	----------	----------	105.78	326.13	164.51	----------	755.00	----------	26,670.28	----------	26,670.28
Ohio	100,696.90	1,535.49	89.58	----------	321.00	----------	573.41	4,808.51	9,237.60	1,590.56	----------	----------	118,853.05	----------	118,853.05
Oklahoma	41,309.80	1,389.91	----------	----------	165.07	----------	1,406.41	17,079.62	2,496.87	----------	----------	----------	63,847.68	----------	63,847.68
Oregon	24,755.40	563.98	5.93	10.79	48.01	----------	2,226.46	2,237.58	5,382.06	----------	----------	----------	35,230.21	----------	35,230.21
Pennsylvania	121,570.33	12,577.15	31.88	16.03	146.94	1,199.19	919.84	11,977.65	6,076.32	802.45	----------	----------	155,317.78	----------	155,317.78
Puerto Rico	50,401.26	854.69	13.93	----------	323.25	1,467.50	43.00	11,759.60	1,173.18	----------	----------	----------	66,036.41	----------	66,036.41
Rhode Island	5,988.90	65.53	2.06	----------	----------	----------	----------	200.63	----------	----------	----------	----------	6,257.12	----------	6,257.12
South Carolina	57,169.59	417.17	488.94	172.98	632.15	7.12	848.89	6,418.12	1,745.06	211.22	----------	----------	68,111.24	----------	68,111.24
South Dakota	17,645.31	113.26	56.08	9.39	----------	134.14	92.71	6,113.73	2,346.16	----------	----------	----------	26,510.78	----------	26,510.78
Tennessee	81,224.47	1,058.82	64.84	3.44	136.60	53.94	659.81	4,791.50	2,349.37	1,951.11	----------	----------	92,293.90	----------	92,293.90
Texas	116,585.98	2,702.95	39.80	381.05	168.86	491.15	9,344.57	12,405.74	7,142.54	1,198.94	----------	----------	150,461.58	----------	150,461.58
Utah	10,913.85	----------	----------	----------	----------	----------	13.86	21.38	1,550.00	----------	----------	----------	12,499.09	----------	12,499.09
Vermont	10,964.16	100.16	2.99	69.70	78.90	----------	80.04	780.68	431.10	----------	360.60	15.73	12,884.06	----------	12,884.06
Virginia	86,151.53	207.24	4.53	----------	----------	290.00	146.24	1,173.25	639.76	----------	----------	----------	88,612.55	----------	88,612.55
Washington	35,817.83	300.66	40.97	.55	----------	----------	205.46	4,351.79	3,233.60	----------	----------	----------	43,950.86	----------	43,950.86
West Virginia	53,820.48	1,839.00	4.42	----------	7.46	437.08	110.85	6,115.91	3,457.08	----------	----------	----------	65,792.28	2.00	65,794.28
Wisconsin	57,519.14	504.42	41.96	----------	67.66	----------	170.14	14,469.30	486.53	----------	----------	----------	73,259.15	----------	73,259.15
Wyoming	6,525.00	85.48	2.21	11.63	----------	----------	190.91	541.05	306.65	----------	----------	----------	7,662.93	----------	7,662.93
Total	2,361,037.52	49,530.33	2,240.87	2,766.49	7,899.10	10,948.87	41,011.50	268,585.67	101,228.84	8,440.74	7,921.60	1,701.16	2,863,312.69	395.31	2,863,708.00

TABLE 9.—*Expenditures and funds available under the Bankhead-Jones Act, title I, secs. 9 (b) 1 and 9 (b) 2, for the year ended June 30, 1952*

Station	Expenditures													Unexpended balances	Funds available [1]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$84,436.78	$5,490.09	$480.42	$350.49	$1,603.50	$1,234.00	$2,350.60	$21,531.05	$12,909.40	$6,546.65			$136,932.98		$136,932.98
Alaska	19,507.69	553.59				22.24	51.19	1,535.17	229.12				21,899.00		21,899.00
Arizona	19,441.73	3,203.36	246.28	148.38	24.80	78.10	1,566.62	5,462.98	4,061.99				34,234.24		34,234.24
Arkansas	82,224.62	3,900.63			940.26	2,820.68	2,986.98	6,071.75	10,009.76		$967.50		109,922.18		109,922.18
California	94,748.18												94,748.18		94,748.18
Colorado	35,621.19	1,057.73	147.64	63.88	43.41	700.77	2,270.94	4,131.24	1,697.94		1,527.92		47,262.66		47,262.66
Connecticut:															
State	14,242.78	235.12					184.95	1,744.08	3,155.07				19,562.00	$605.87	20,167.87
Storrs	13,127.71	266.19		10.00		197.14	13.20	1,339.86	4,252.52				19,206.62	304.32	19,510.94
Delaware	19,138.29	2,366.07				540.75	485.95	670.11	3,898.41				27,099.58	2.70	27,102.28
Florida	49,387.70	5,690.23		40.63	165.50		524.83	7,289.18	2,393.16				65,491.23	61.61	65,552.84
Georgia	105,495.45	4,547.74	85.13	7.20			365.00	14,510.71	5,050.27				130,061.50		130,061.50
Hawaii	23,917.62	2,384.06	37.37	59.57			5,435.33	867.78	5,050.21				37,751.94	152.00	37,903.94
Idaho	27,237.27	5,127.40	148.09	28.43	113.70		98.55	7,509.96	389.78	128.53			40,781.71		40,781.71
Illinois	91,534.79	1,735.60	19.08	4.20	1.00	344.28	2,011.40	14,147.85	8,374.81		2,878.84		121,051.85		121,051.85
Indiana	79,474.20	575.10	31.29	20.21	72.35		1,136.73	6,870.67	3,083.00	994.20			92,257.75	2,532.56	94,790.31
Iowa	89,643.46												89,643.46		89,643.46
Kansas	56,499.24	830.55		20.10	562.00	212.04	692.34	5,694.09	805.41			$576.90	65,892.67		65,892.67
Kentucky	85,597.40	3,920.77	53.50	244.72		2,405.66	1,079.10	16,201.09	7,500.68			987.09	117,990.01		117,990.01
Louisiana	72,879.37	3,725.21	197.60	100.20	388.08	625.59	974.46	10,212.35	1,506.15	1,346.01			91,955.02		91,955.02
Maine	29,937.89	1,982.74	45.72	60.73	330.40	404.83	100.17	3,596.77	718.10				37,177.35		37,177.35
Maryland	35,740.50	270.12	20.40	24.14	106.45	1,371.23	1,278.04	7,846.47	5,518.78	654.16			52,830.29		52,830.29
Massachusetts	24,057.49	2,384.35	33.94			143.70	1,259.36	9,190.13	5,604.99				42,673.96		42,673.96
Michigan	105,530.89	1,635.37	2.18	11.75	25.00	64.40	249.77	662.07	478.83				108,660.26		108,660.26
Minnesota	76,627.40	5,068.94	168.83	337.53	44.18	4,767.32	4,458.27	9,666.59	10,303.45				111,442.51		111,442.51
Mississippi	95,141.57	5,348.93	108.20	378.43	2,468.26	855.85	1,499.12	9,742.49	2,790.84	3,328.15			121,661.84		121,661.84
Missouri	79,593.55	2,800.27	403.26	223.51	434.24	63.97	6,553.55	5,490.81	4,862.78			722.50	101,148.44		101,148.44
Montana	30,746.36	829.60	68.33	32.20		3.50	1,000.47	1,426.79	1,482.75				35,590.00		35,590.00
Nebraska	54,601.87	1,433.87	19.12	2.55	7.00	2.40	284.83	849.25	2,120.54				59,321.43		59,321.43
Nevada	15,403.65	273.18	267.53	153.60	331.21		277.12	3,592.10	1,553.98				21,852.37		21,852.37
New Hampshire	25,778.54	358.31	18.72	23.46	102.62	32.90		1,230.13	225.00				27,769.68		27,769.68

New Jersey	30,739.28	1,565.22	156.19	12.79	120.00	254.97	1,843.89	3,098.34	4,043.32				41,834.00		41,834.00
New Mexico	29,627.57	1,386.29	252.09	37.38	233.37		2,342.48	3,145.07	1,032.54				38,056.79		38,056.79
New York:															
Cornell	65,339.38	5,599.28	85.90	223.42	122.51	1,697.43	7,221.71	10,954.09	13,144.94				104,388.66	351.44	104,740.10
State	5,893.62	81.55	77.30				871.83	1,273.98	3,638.91				11,837.19		11,837.19
North Carolina	125,607.20	2,318.25	79.72	186.31	921.37		2,372.69	9,139.73	13,591.79				154,217.06		154,217.06
North Dakota	44,506.56	1,359.80	39.38	53.06	626.85	27.82	166.65	2,085.31	337.42		1,218.65		50,421.50		50,421.50
Ohio	116,808.88	3,955.36	183.55	360.00	1.28	398.74	1,181.30	5,967.37	39,860.18	6,004.94			174,721.60		174,721.60
Oklahoma	61,793.83	1,504.20		43.80	1,781.71		6,357.83	9,659.51	6,962.22	1,043.41			89,146.51		89,146.51
Oregon	42,305.38	2,468.91	8.06	38.69			484.91	1,764.30	2,572.69				49,642.94	4.05	49,646.99
Pennsylvania	104,876.27	2,524.60	52.61	12.90		2,534.54	914.44	18,761.81	6,155.91	7,419.80			143,252.88		143,252.88
Puerto Rico	67,335.26	2,642.43	74.56		125.00	1,880.15	270.43	23,302.45	11,117.04				106,747.32	512.99	107,260.31
Rhode Island	23,591.17	543.15	1.50		381.63	250.00	15.60	2,761.71	37.54				27,582.30		27,582.30
South Carolina	72,638.02	2,202.86	103.08	301.19	1,195.68	2,224.27	2,156.57	7,746.79	5,580.95	1,771.22			95,920.63		95,920.63
South Dakota	31,529.82	1,735.49	78.44	94.58	6.00	744.10	1,729.13	10,635.47	5,611.64				52,164.67		52,164.67
Tennessee	98,841.45	1,948.13	126.87	102.20	277.39	45.50	1,155.25	9,313.39	5,934.37	415.86			118,160.41		118,160.41
Texas	123,803.14	6,002.68	431.10	709.02	625.95	776.13	15,243.41	21,029.66	10,554.25	248.68			179,424.02		179,424.02
Utah	19,740.27	259.16	44.14	132.99	724.00		194.78	7,912.42	1,262.64				30,270.40		30,270.40
Vermont	27,881.72	1,309.48	20.74	10.10	52.07		122.81	1,337.26	1,777.60	617.49	790.67	112.07	34,532.01		34,532.01
Virginia	93,399.16	2,489.60	20.78	30.00	191.56	1,613.57	5,014.64	4,614.78	5,400.93				112,775.02		112,775.02
Washington	49,118.00	1,583.39	161.40	15.72	77.00	343.00	2,626.94	11,288.14	8,194.38				73,407.97		73,407.97
West Virginia	73,326.54	6,313.83	3.59		125.40	2,728.67	976.30	9,022.65	6,330.70	534.59			99,362.27		99,362.27
Wisconsin	53,847.45	1,936.57	26.93		6.73	654.91	333.18	11,550.41	4,203.63				72,559.81	16,913.32	89,473.13
Wyoming	18,832.96	2,665.99	174.85	190.07			260.01	2,936.91	6,305.43				31,366.22		31,366.22
Total	3,018,698.11	122,391.34	4,805.41	4,900.13	15,359.46	33,065.15	93,045.65	368,885.07	273,678.74	31,053.69	7,383.58	2,398.56	3,975,664.89	21,440.86	3,997,105.75

[1] Include allotments from the appropriation for fiscal year 1952 plus unexpended balances of allotments from appropriation for fiscal year 1951.

TABLE 10.—*Expenditures and funds available under the Bankhead-Jones Act, title I, sec. 9 (b) 3, for the year ended June 30, 1952*

Station	Expenditures													Unexpended	Funds available [1]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total expenditures		
Alabama	$14,765.75	$1,099.75	$55.98	$61.24	$125.00	$873.00		$178.19	$4,512.75				$21,671.66		$21,671.66
Alaska															
Arizona	11,988.49	1,369.02	54.16	20.40	109.25	660.56	$164.92	3,627.04	675.94	$4,429.45			23,099.23	$590.93	23,690.16
Arkansas	16,501.69	3,489.18			446.06		360.46	1,368.86	706.56		$130.00		23,002.81	150.85	23,153.66
California	20,070.74	2,494.93		2.79		4,365.19	2.74	11.34	74.28				27,022.01		27,022.01
Colorado	27,149.23	4,757.09	50.66	73.43	753.43	7,250.75	1,815.55	4,106.93	2,283.59		689.62		48,930.28	475.61	49,405.89
Connecticut:															
State		101.72											101.72		101.72
Storrs	14,271.28	1,166.28	1.68			749.76	7.78	1,780.99	1,631.74				19,609.51	699.11	20,308.62
Delaware	2,500.00	30.52		1.28				685.23	282.97				3,500.00		3,500.00
Florida	7,926.00	2,906.15			213.89	557.00	485.43	740.13	2,736.75				15,565.35	22.91	15,588.26
Georgia	32,435.45	3,573.12	60.02	2.95		7,460.36	23.04	4,020.76	2,217.54				49,793.24		49,793.24
Hawaii	3,100.47	551.86		12.00		1,000.00	8.10	18.00	5.23				4,695.66	304.34	5,000.00
Idaho	12,894.21	476.29		7.10			8.00	2,972.77	11.00				16,369.37		16,369.37
Illinois	13,910.89	839.88	61.65	10.49		1,486.92	3,619.31	4,120.99	4,084.13		439.19		28,573.45		28,573.45
Indiana	24,065.45	3,353.74	111.48	9.65	14.00		810.35	17,667.11	2,379.51	2,534.07		$265.66	51,211.02	449.83	51,660.85
Iowa	29,064.53	6,620.50	108.80	344.51	10.22	541.87		21,775.26	5,552.27				64,017.96		64,017.96
Kansas	12,398.81	1,248.84	112.79	117.60	37.00	180.88	3,563.09	7,018.69	1,255.96	62.62		73.34	26,069.62	.93	26,070.55
Kentucky	7,673.00	619.90		218.47				79.65				61.78	8,652.80		8,652.80
Louisiana	16,875.24	1,924.04	7.77	11.00	551.31	310.48	767.63	2,347.70	2,102.80	827.19			25,725.16		25,725.16
Maine	21,932.36	3,575.67	49.65	83.17	275.00		858.04	945.11	681.00				28,400.00		28,400.00
Maryland	7,749.79	1,733.00	16.62	22.66	118.66	735.23	858.13	5,199.64	1,974.04	15.60			18,423.37	359.19	18,782.56
Massachusetts	8,000.00					1,069.25	2,500.00						11,569.25		11,569.25
Michigan	14,269.80	2,895.41	8.21	240.66		4,568.36	1,735.44	1,895.34	1,327.64				26,940.86		26,940.86
Minnesota	32,213.33	4,026.09	30.30	381.92	58.35	718.39	2,083.52	3,653.92	735.79				43,901.61	29.42	43,931.03
Mississippi	35,800.65	2,297.46	376.50	373.78	217.48	1,064.94	1,017.75	3,832.67	191.97				45,173.20		45,173.20
Missouri	17,828.44	675.58	212.24	231.50	97.96		658.22	2,457.21	1,038.16	23.20		127.49	23,350.00		23,350.00
Montana	28,145.94	4,135.43	438.29	151.60	248.00	796.60	2,396.27	3,514.81	555.01				40,381.95	110.73	40,492.68
Nebraska	19,233.86	745.14	144.42	6.00	20.00		1.20	94.31	373.23				20,618.16		20,618.16
Nevada	4,950.00	32.50		372.70	27.07		1.75	2,893.91	122.07				8,400.00		8,400.00
New Hampshire	3,741.55	596.12		26.80		86.33		1,148.45	800.75				6,400.00		6,400.00

New Jersey	22,612.28	1,282.04	13.01	21.78	296.57	214.00	118.58	1,861.85	1,645.45				28,065.56	578.00	28,643.56
New Mexico	15,343.55	1,043.96	68.18	15.28			240.91	2,504.07	1,392.98				20,608.93		20,608.93
New York:															
Cornell	35,264.93	4,388.35	256.56	560.78	33.28	1,608.78	5,022.04	4,467.37	7,714.21				59,316.30	161.79	59,478.09
State															
North Carolina	28,457.54	7,497.17		85.98	30.00		467.12	1,758.41	2,797.76				41,093.98	39.85	41,133.83
North Dakota	3,463.27	1,184.14	2.28	70.92	14.40	.70	554.02	48.43	55.65		88.50		5,482.31		5,482.31
Ohio	17,898.59	1,036.33						61.71	448.02				19,444.65		19,444.65
Oklahoma	6,226.75	1,957.68	28.64		11.84	10.62	1,161.35	5,079.60	7,851.00				22,327.48		22,327.48
Oregon	34,084.71	1,904.89		205.52		735.55	1,300.85	3,696.32	1,355.56				43,283.40		43,283.40
Pennsylvania	18,519.44	827.15	4.20	55.80			5,310.98	6,764.39	5,381.77	1,933.00			38,796.73		38,796.73
Puerto Rico	3,275.12							222.55					3,497.67	2.33	3,500.00
Rhode Island	25,254.99	915.91					54.33	1,241.07	65.27				27,531.57		27,531.57
South Carolina	22,671.76	588.27	18.82	91.14	50.00	4,693.50	819.03	1,592.11	1,334.38				31,859.01		31,859.01
South Dakota	11,580.32	424.24	12.01	104.45		189.35	674.89	3,275.28	1,536.08				17,796.62		17,796.62
Tennessee	24,482.24	534.71	29.93	2.07			278.60	3,322.93	866.14	1,209.12			30,725.74		30,725.74
Texas	47,770.20	6,696.15	27.15	523.24	562.27	410.55	1,676.91	4,635.40	2,929.58				65,231.45		65,231.45
Utah	31,130.52	3,185.64	429.50	23.99	1,781.45	3,578.14	1,504.88	9,695.02	1,597.86	186.40			53,113.40	175.62	53,289.02
Vermont	2,986.89	517.50	41.49	22.98	33.95	1,005.60	9.36	2,044.72	635.00		111.90	8.13	7,417.52		7,417.52
Virginia	16,988.73	1,723.68				2,635.88	1,850.00	25.15	1,301.56				24,525.00		24,525.00
Washington	32,703.68	7,411.88	330.26	302.58	145.50	89.57	643.61	8,761.88	11,813.26				62,202.22	2,837.28	65,039.50
West Virginia	25,102.31	2,130.16	20.39	30.00		659.58	148.56	3,287.30	5,356.17				36,734.47	.06	36,734.53
Wisconsin	21,733.40	5,068.53	31.73	105.58	28.84	1,296.38	173.30	8,303.01	7,955.90	20,613.82			65,310.49	1,281.59	66,592.08
Wyoming	10,779.40	2,417.79	67.03	39.26	117.01	1,729.01	41.00	1,885.74	1,234.73				18,310.97		18,310.97
Total	919,787.57	110,071.38	3,282.40	5,045.05	6,427.79	53,333.08	45,797.04	172,689.32	103,581.01	31,834.47	1,459.21	536.40	1,453,844.72	8,270.37	1,462,115.09

[1] Include allotments from the appropriation for fiscal year 1952 plus unexpended balances of allotments from appropriation for fiscal year 1951.

TABLE 11.—*Expenditures from non-Federal funds for the year ended June 30, 1952*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Taxes and assessments	Total	Unexpended balances
Alabama	$623,729.62	$37,908.15	$7,849.89	$7,092.76	$19,116.96	$4,272.32	$38,559.49	$390,912.60	$101,964.42	$34,052.30	$2,158.27		$1,267,616.78	$364,965.88
Alaska	85,669.62	1,857.55	1,301.68	124.90	630.25	1,385.75	8,596.28	18,753.21	5,963.22	15,957.69		$1,432.02	141,672.17	77,140.17
Arizona	307,510.61	9,397.20	904.46	2,954.49	8,404.39	5,679.68	16,705.80	37,354.85	29,577.30			4,368.39	422,857.17	
Arkansas	320,151.11	26,296.62	1,826.51	3,251.76	14,708.25	6,394.01	33,405.10	146,398.76	21,265.07	8,183.44	3,115.20		584,995.83	133,296.43
California	4,102,255.12	169,952.64	6,218.22	60,355.47	49,070.17	89,653.86	183,689.57	320,554.45	182,811.64				5,164,561.14	450,009.29
Colorado	295,987.78	14,176.58	2,112.50	4,784.26	38,375.85	9,861.64	26,471.06	109,176.66	60,303.62	871.20	7,826.41		569,947.56	181,005.54
Connecticut:														
State	287,540.05	2,133.33	339.35	2,186.01	7,504.94	4,085.99	12,905.54	25,613.46	8,590.99				350,899.66	37,160.56
Storrs	265,459.00	2,766.55	245.41	11.65	1,701.30	6,792.25	1,941.88	36,440.20	9,541.31				324,899.55	47,281.71
Delaware	149,137.49	5,762.12	1,007.76	2,852.94	4,472.87	641.36	11,770.52	90,195.78	14,220.17	2,743.42			282,804.43	52,278.45
Florida	1,827,529.20	64,886.89	4,559.83	13,966.21	44,298.28	14,934.27	60,585.77	370,499.56	121,885.45	336,184.86			2,859,330.32	550,524.84
Georgia	233,678.42	10,446.20	1,970.35	3,109.18	10,533.14	4,381.11	15,303.79	113,563.32	18,193.53	63,380.01	244.32		474,803.37	218,163.15
Hawaii	377,416.34	5,953.26	1,118.32	2,545.59	6,541.17	4,640.26	17,307.66	57,194.32	17,746.40	607.00			491,070.32	9,817.40
Idaho	292,127.00	11,314.75	5,075.00	9,140.00	11,000.00	1,560.00	2,550.00	72,699.82	35,116.12	99,300.00		90.00	539,972.69	178,345.81
Illinois	1,468,696.72	96,000.00		27,000.00		55,000.00		357,447.95	72,278.21	11,616.57			2,088,039.45	
Indiana	1,090,263.66	36,021.07	8,565.14	16,665.68	15,822.39	103,478.73	106,780.62	621,405.06	138,731.57	97,370.64			2,235,104.56	569,710.22
Iowa	1,026,052.36	91,433.06	4,696.98	7,462.92	8,104.37	28,036.61		730,198.84	119,772.40	48,754.91	29,240.19	34,059.01	2,127,811.65	317,490.27
Kansas	669,143.00	12,672.85	11,622.84	4,875.87	15,636.25	6,134.78	49,196.35	175,214.20	9,912.08	26,354.83		937.17	1,061,700.22	233,175.84
Kentucky	441,976.98	12,327.49	383.05	6,089.47	9,058.88	6,028.67	40,470.09	93,063.10	30,242.98			4,228.71	643,869.42	364.62
Louisiana	871,099.16	40,664.62	2,578.56	8,193.21	21,934.74	5,843.81	114,218.24	240,232.28	47,522.96	50,822.52			1,403,110.10	
Maine	165,013.48	11,576.52	750.62	2,530.58	8,061.43	4,036.84	11,611.69	29,697.61	13,126.87	4,507.84			250,913.48	44,040.58
Maryland	303,278.53	13,098.96	548.76	1,712.72	2,014.03	3,590.67	27,950.03	137,729.73	43,760.93	8,190.47			541,874.83	98,386.46
Massachusetts	422,340.77	8,648.04	1,043.66	5,064.98	1,395.60	2,310.97	5,753.35	23,646.31	10,143.67				480,347.35	30,822.92
Michigan	991,893.80	43,389.83	3,269.61	5,981.88	7,307.23	25,283.37	61,998.69	172,378.06	53,762.97				1,365,265.44	78,158.15
Minnesota	1,381,710.02	26,275.38	5,842.70	11,657.13	26,293.65	9,664.65	144,897.91	328,044.30	114,095.62	6,685.24			2,055,166.60	
Mississippi	589,922.23	15,106.93	8,854.96	6,832.26	40,340.52	17,182.41	99,126.44	331,243.21	148,966.01	10,678.26			1,268,253.23	243,990.14
Missouri	335,625.73	21,327.85	2,772.02	3,051.11	6,255.27	23,796.40	46,450.68	140,827.55	47,875.75	166,808.44		4,739.70	799,530.50	416,409.18
Montana	445,210.73	11,665.54	3,931.29	3,778.40	32,424.42	4,483.21	26,668.72	180,973.71	31,279.81	15,012.61	17,347.75		772,776.19	226,954.45
Nebraska	560,023.92	31,149.64	7,747.57	4,371.44	13,406.36	11,161.99	3,469.55	256,273.02	256,672.50	4,439.53		3,189.70	1,151,905.22	83,773.97
Nevada	34,965.47	2,753.49	71.61	613.18	1,374.84	129.75	3,749.06	11,835.81	8,870.71	1,036.74			65,400.66	43,649.72
New Hampshire	50,616.92	4,066.25	210.71	402.95		698.50	124.79	7,084.38	1,686.50				64,891.00	1,743.18
New Jersey	853,113.21	31,786.77	2,948.25	17,171.66	38,044.04	11,170.61	104,835.75	161,530.20	50,264.58		190.80		1,271,055.87	7,769.25
New Mexico	169,803.02	5,206.17	1,360.63	1,298.98	5,982.88	3,203.40	20,137.11	41,284.14	22,877.41	280.61	6,910.14		278,344.49	157,269.90

New York:														
Cornell	1,994,010.93	32,267.22	4,423.58	22,683.52	110,441.15	18,010.09	157,570.65	319,906.54	103,055.92	9,591.75			2,771,961.35	
State	729,478.93	8,692.83	1,388.05	4,679.02	12,910.16	12,090.53	13,113.68	72,733.65	38,530.82				893,617.67	
North Carolina	990,324.40	30,338.85	2,690.56	11,063.20	18,921.52	15,317.03	69,383.02	172,142.93	82,295.80	17,604.99			1,410,082.30	
North Dakota	333,693.83	8,604.97	2,240.72	3,316.47	25,283.08	10,313.38	24,887.88	99,805.28	48,377.77	96,543.59	6,892.75		659,959.72	119,644.36
Ohio	782,527.67	14,220.49	5,748.57	9,177.44	21,670.49	9,678.61	38,556.01	315,120.58	76,068.52	260,824.05			1,533,592.43	333,011.07
Oklahoma	631,244.54	28,498.80	2,638.86	4,604.22	21,820.46	11,185.94	62,234.90	291,075.49	88,885.07	119,935.43	3,377.72		1,265,501.43	162,981.51
Oregon	1,142,942.89	63,573.46	7,251.84	11,699.08	19,396.24	16,813.65	46,017.86	266,442.39	88,503.33	107,333.71	51,493.92	5,036.78	1,826,505.15	
Pennsylvania	792,615.18	26,889.87	1,672.35	2,834.34	13,421.41	14,310.97	4,668.99	181,452.43	36,275.26	8,440.70			1,082,581.50	92,546.11
Puerto Rico	295,779.90	14,795.16	2,084.49	3,759.57	12,504.41	21,195.50	48,370.36	193,715.29	170,032.82	63,999.90	24,520.11	7,025.90	857,783.41	165,399.59
Rhode Island	73,716.96	1,276.21	53.70	533.92	848.18	259.06	1,110.46	13,466.19	3,639.52	248.00			95,152.20	28,033.46
South Carolina	420,194.70	10,700.28	1,102.57	3,047.22	7,393.36	5,816.14	37,117.74	157,970.59	66,011.85	14,531.94			723,886.39	40,970.91
South Dakota	236,120.31	9,276.26	835.46	617.07	1,220.79	4,363.34	2,563.68	121,937.06	40,436.70				417,370.67	62,573.02
Tennessee	356,905.10	8,433.00	4,828.96	5,729.27	6,424.27	4,375.96	24,592.32	144,551.57	45,787.08	10,502.26			612,129.79	
Texas	1,293,230.43	37,032.56	2,869.20	17,042.74	37,005.08	9,031.16	294,709.24	352,886.95	260,038.25	96,168.41	24,131.85	52,264.77	2,476,410.64	907,952.03
Utah	298,405.58	16,786.07	2,302.33	2,449.34	9,568.52	3,326.95	11,942.55	92,559.72	51,910.73	23,359.34	1,446.89		514,058.02	167,997.97
Vermont	51,350.56	2,401.41	295.56	1,098.30	6,349.85	77.58	15,272.77	6,373.68	5,252.60	1,307.13	1,140.96	1,210.62	92,131.02	19,865.74
Virginia	477,457.97	27,734.66	2,959.50	8,640.41	14,829.70	2,828.06	26,000.05	118,401.91	37,306.77	269,209.98			985,369.81	
Washington	1,216,728.41	55,767.24	10,039.57	9,710.40	19,338.51	14,812.48	53,078.05	304,509.75	126,303.81	4,306.77	44,029.54		1,858,624.53	
West Virginia	179,134.61	5,264.32	1,017.43	1,105.46	10,998.98	277.07	34,220.77	95,277.98	48,847.91	69,395.88			445,540.41	85,295.13
Wisconsin	1,837,953.00	29,492.00	3,112.00	2,417.00	7,312.00	10,641.00	60,738.00	421,211.00	139,318.00	21,962.00			2,534,156.00	
Wyoming	213,087.28	24,384.40		6,049.39	6,808.86	5,043.16	10,810.18	96,270.95	59,789.23	4,404.83			426,648.28	76,285.11
Total	35,385,844.25	1,334,452.36	161,283.54	379,387.02	854,281.49	665,286.33	2,334,190.69	9,667,278.38	3,545,690.53	2,213,509.79	224,066.82	118,582.77	56,883,853.97	7,116,254.09

TABLE 12.—*Summary by States of expenditures of the experiment stations for the year ended June 30, 1952*

Station	Federal-grant funds							Contractural Federal funds, Agricultural Marketing Act, title II	Non-Federal funds	Grand total
	Hatch	Adams	Purnell	Bankhead-Jones, title I			Total			
				Sec. 5	Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3				
Alabama	$15,000.00	$15,000.00	$60,000.00	$88,305.89	$136,932.98	$21,671.66	$336,910.53	$3,248.59	$1,267,616.78	$1,607,775.90
Alaska	15,000.00	15,000.00	35,000.00	4,736.40	21,899.00		91,635.40		141,672.17	233,307.57
Arizona	15,000.00	15,000.00	60,000.00	16,740.68	34,234.24	23,099.23	164,074.15		422,857.17	586,931.32
Arkansas	15,000.00	15,000.00	60,000.00	66,187.20	109,922.18	23,002.81	289,112.19		584,995.83	874,108.02
California	15,000.00	15,000.00	60,000.00	102,716.44	94,748.18	27,022.01	314,486.63	8,290.52	5,164,561.14	5,487,338.29
Colorado	15,000.00	15,000.00	60,000.00	25,460.16	47,262.66	48,930.28	211,653.10		569,947.56	781,600.66
Connecticut:										
State	7,500.00	7,500.00	29,904.50	11,256.83	19,562.00	101.72	75,825.05		350,899.66	426,724.71
Storrs	7,042.59	7,500.00	29,999.96	11,247.85	19,206.62	19,609.51	94,606.53	4,958.68	324,899.55	424,464.76
Delaware	14,999.93	15,000.00	60,000.00	5,970.02	27,099.58	3,500.00	126,569.53		282,804.43	409,373.96
Florida	15,000.00	15,000.00	60,000.00	47,664.95	65,491.23	15,565.35	218,721.53	5,729.16	2,859,330.32	3,083,781.01
Georgia	15,000.00	15,000.00	60,000.00	98,402.95	130,061.50	49,793.24	368,257.69	16,186.11	474,803.37	859,247.17
Hawaii	15,000.00	15,000.00	60,000.00	10,463.17	37,751.94	4,695.66	142,910.77	6,127.96	491,070.32	640,109.05
Idaho	15,000.00	15,000.00	60,000.00	16,866.19	40,781.71	16,369.37	164,017.27		539,972.69	703,989.96
Illinois	15,000.00	15,000.00	60,000.00	99,478.95	121,051.85	28,573.45	339,104.25	8,312.37	2,088,039.45	2,435,456.07
Indiana	15,000.00	15,000.00	60,000.00	79,141.32	92,257.75	51,211.02	312,610.09	27,848.87	2,235,104.56	2,575,563.52
Iowa	15,000.00	15,000.00	60,000.00	74,227.20	89,643.46	64,017.96	317,888.62	21,414.84	2,127,811.65	2,467,115.11
Kansas	15,000.00	15,000.00	60,000.00	53,057.23	65,892.67	26,069.62	235,019.52	9,998.65	1,061,700.22	1,306,718.39
Kentucky	15,000.00	15,000.00	60,000.00	93,378.88	117,990.01	8,652.80	310,021.69		643,869.42	953,891.11
Louisiana	15,000.00	15,000.00	60,000.00	60,813.78	91,955.02	25,725.16	268,493.96		1,403,110.10	1,671,604.06
Maine	15,000.00	15,000.00	60,000.00	22,270.68	37,177.35	28,400.00	177,848.03	7,500.00	250,913.48	436,261.51
Maryland	15,000.00	15,000.00	60,000.00	36,488.62	52,830.29	18,423.37	197,742.28	5,187.16	541,874.83	744,804.27
Massachusetts	15,000.00	15,000.00	60,000.00	36,698.19	42,673.96	11,569.25	180,941.40		480,347.35	661,288.75
Michigan	15,000.00	15,000.00	60,000.00	93,777.64	108,660.26	26,940.86	319,378.76	41,947.21	1,365,265.44	1,726,591.41
Minnesota	15,000.00	15,000.00	60,000.00	68,127.21	111,442.51	43,901.61	313,471.33		2,055,166.60	2,368,637.93
Mississippi	15,000.00	15,000.00	60,000.00	80,016.75	121,661.84	45,173.20	336,851.79	33,995.97	1,268,253.23	1,639,100.99
Missouri	15,000.00	15,000.00	60,000.00	78,849.57	101,148.44	23,350.00	293,348.01	6,000.00	799,530.50	1,098,878.51
Montana	15,000.00	15,000.00	60,000.00	18,004.00	35,590.00	40,381.95	183,975.95		772,776.19	956,752.14
Nebraska	15,000.00	15,000.00	60,000.00	41,343.56	59,321.43	20,618.16	211,283.15	1,276.91	1,151,905.22	1,364,465.28
Nevada	15,000.00	15,000.00	60,000.00	3,435.49	21,852.37	8,400.00	123,687.86		65,400.66	189,088.52
New Hampshire	15,000.00	15,000.00	60,000.00	11,363.43	27,769.68	6,400.00	135,533.11		64,891.00	200,424.11
New Jersey	15,000.00	15,000.00	60,000.00	32,575.43	41,834.00	28,065.56	192,474.99	3,897.39	1,271,055.87	1,467,428.25
New Mexico	15,000.00	15,000.00	60,000.00	17,027.28	38,056.79	20,608.93	165,693.00		278,344.49	444,037.49

New York:										
Cornell	13,493.58	13,500.00	53,895.53	97,003.10	104,388.66	59,316.30	341,597.17	5,121.74	2,771,961.35	3,118,680.26
State	1,499.40	1,495.64	5,999.14	10,778.06	11,837.19		31,609.43	10,174.80	893,617.67	935,401.90
North Carolina	15,000.00	15,000.00	60,000.00	135,186.64	154,217.06	41,093.98	420,497.68	3,271.46	1,410,082.30	1,833,851.44
North Dakota	15,000.00	15,000.00	60,000.00	26,670.28	50,421.50	5,482.31	172,574.09		659,959.72	832,533.81
Ohio	15,000.00	15,000.00	60,000.00	118,853.05	174,721.60	19,444.65	403,019.30	10,000.00	1,533,592.43	1,946,611.73
Oklahoma	15,000.00	15,000.00	60,000.00	63,847.68	89,146.51	22,327.48	265,321.67		1,265,501.43	1,530,823.10
Oregon	15,000.00	15,000.00	60,000.00	35,230.21	49,642.94	43,283.40	218,156.55	2,002.13	1,826,505.15	2,046,663.83
Pennsylvania	15,000.00	15,000.00	60,000.00	155,317.78	143,252.88	38,796.73	427,367.39		1,082,581.50	1,509,948.89
Puerto Rico	16,000.00	15,000.00	59,536.75	66,036.41	106,747.32	3,497.67	265,818.15	6,514.21	857,783.41	1,130,115.77
Rhode Island	15,000.00	14,990.82	60,000.00	6,257.12	27,582.30	27,531.57	151,361.81		95,152.20	246,514.01
South Carolina	15,000.00	15,000.00	60,000.00	68,111.24	95,920.63	31,859.01	285,890.88		723,886.39	1,009,777.27
South Dakota	15,000.00	15,000.00	60,000.00	26,510.78	52,164.67	17,796.62	186,472.07		417,370.67	603,842.74
Tennessee	15,000.00	15,000.00	60,000.00	92,293.90	118,160.41	30,725.74	331,180.05	10,192.85	612,129.79	953,502.69
Texas	15,000.00	15,000.00	60,000.00	150,461.58	179,424.02	65,231.45	485,117.05	16,001.52	2,476,410.64	2,977,529.21
Utah	15,000.00	15,000.00	60,000.00	12,499.09	30,270.40	53,113.40	185,882.89		514,058.02	699,940.91
Vermont	15,000.00	15,000.00	60,000.00	12,884.06	34,532.01	7,417.52	144,833.59		92,131.02	236,964.61
Virginia	15,000.00	15,000.00	60,000.00	88,612.55	112,775.02	24,525.00	315,912.57		985,369.81	1,301,282.38
Washington	15,000.00	14,999.23	60,000.00	43,950.86	73,407.97	62,202.22	269,560.28	6,244.82	1,858,624.53	2,134,429.63
West Virginia	14,997.45	15,000.00	60,000.00	65,792.28	99,362.27	36,734.47	291,886.47	1,800.00	445,540.41	739,226.88
Wisconsin	15,000.00	15,000.00	60,000.00	73,259.15	72,559.81	65,310.49	301,129.45	8,660.35	2,534,156.00	2,843,945.80
Wyoming	15,000.00	15,000.00	60,000.00	7,662.93	31,366.22	18,310.97	147,340.12		426,648.28	573,988.40
Total	764,532.95	764,985.69	3,034,335.88	2,863,312.69	3,975,664.89	1,453,844.72	12,856,676.82	291,904.27	56,883,853.97	70,032,435.06

TABLE 13.—*Summary by classification of expenditures of the experiment stations for the year ended June 30, 1952*

	Account	Hatch Act	Adams Act	Purnell Act	Bankhead-Jones Act, title I			Total	Contractual Federal funds, Agricultural Marketing Act, title II	Non-Federal funds	Grand total
					Sec. 5	Secs. 9 (b) 1 and 9 (b) 2	Sec. 9 (b) 3				
01	Personal services	$616,829.43	$679,668.89	$2,589,083.52	$2,361,037.52	$3,018,698.11	$919,787.57	$10,185,105.04	$215,876.46	$35,385,844.25	$45,786,825.75
02	Travel	20,956.29	6,534.83	58,019.34	49,530.33	122,391.34	110,071.38	367,503.51	13,184.72	1,334,452.36	1,715,140.59
03	Transportation of things	340.63	593.70	2,120.66	2,240.87	4,805.41	3,282.40	13,383.67	609.78	161,283.54	175,276.99
04	Communication service	5,721.33	486.17	2,653.98	2,766.49	4,900.13	5,045.05	21,573.15	1,227.33	379,387.02	402,187.50
05	Rents and utility services	2,934.16	1,574.44	12,384.43	7,899.10	15,359.46	6,427.79	46,579.38	1,620.47	854,281.49	902,481.34
06	Printing and reproduction	40,898.95		23,913.06	10,948.87	33,065.15	53,333.08	162,159.11	4,095.54	665,286.33	831,540.98
07	Other contractual services	4,901.24	6,628.16	33,617.67	41,011.50	93,045.65	45,797.04	225,001.26	8,908.32	2,334,190.69	2,568,100.27
08	Supplies and materials	43,763.11	41,678.43	195,938.74	268,585.67	368,885.07	172,689.32	1,091,540.34	25,656.58	9,667,278.38	10,784,475.30
09	Equipment	24,810.36	23,404.07	91,553.17	101,228.84	273,678.74	103,581.01	618,256.19	20,621.48	3,545,690.53	4,184,568.20
10	Lands and structures (contractual)	564.26	1,331.59	14,617.68	8,440.74	31,053.69	31,834.47	87,842.43		2,213,509.79	2,301,352.22
11	Contributions to retirement	2,415.59	2,680.28	8,729.50	7,921.60	7,383.58	1,459.21	30,589.76		224,066.82	254,656.58
15	Taxes and assessments	397.60	405.13	1,704.13	1,701.16	2,398.56	536.40	7,142.98	103.59	118,582.77	125,829.34
	Total	764,532.95	764,985.69	3,034,335.88	2,863,312.69	3,975,664.89	1,453,844.72	12,856,676.82	291,904.27	56,883,853.97	70,032,435.06

TABLE 14.—*Expenditures and allotments under the Agricultural Marketing Act, title II, for the year ended June 30, 1952*

Station	Expenditures												Unexpended	Funds available[1]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Taxes and assessments	Total expenditures		
Alabama	$2,181.85		$1.75	$42.10	$32.21		$13.01	$902.67	$75.00			$3,248.59		$3,248.59
California	8,140.52	$7.50			108.15			34.35				8,290.52		8,290.52
Connecticut (Storrs)	3,458.78	551.53						49.92	898.45			4,958.68	$241.74	5,200.42
Florida	5,729.16											5,729.16	1,811.96	7,541.12
Georgia	14,432.42	906.34	.86	.50				588.30	257.69			16,186.11	4,972.10	21,158.21
Hawaii	4,036.13	641.81		85.50		$1,308.27	4.66	48.09	3.50			6,127.96	3,851.85	9,979.81
Illinois	7,586.92	341.60						172.08	211.77			8,312.37	2,795.20	11,107.57
Indiana	23,217.56	818.69	12.99	9.55			644.74	1,388.53	1,756.81			27,848.87	1,891.67	29,740.54
Iowa	17,238.08	693.41	63.34	12.47		127.71		1,752.67	1,527.16			21,414.84	676.83	22,091.67
Kansas	9,516.67	222.30						156.09			$103.59	9,998.65	2.45	10,001.10
Maine	3,751.57	769.81	52.09	71.79	436.45		24.29	426.14	1,967.86			7,500.00		7,500.00
Maryland	3,363.23	229.35		44.89		838.50	557.92	102.95	50.32			5,187.16	2,408.22	7,595.38
Michigan	35,857.09	1,108.18	5.42	426.41	16.46	1,248.40	2,128.02	267.59	849.64			41,947.21	3,774.40	45,721.61
Mississippi	18,319.68	1,056.49	105.26	175.86	576.33	43.00	359.61	6,392.66	6,967.08			33,995.97	2,269.81	36,265.78
Missouri	1,190.51	386.54	32.70	4.98			249.77	3,798.04	337.46			6,000.00		6,000.00
Nebraska	866.66					410.25						1,276.91		1,276.91
New Jersey	2,512.62	5.00	3.55				110.00	512.59	753.63			3,897.39	6,259.81	10,157.20
New York:														
Cornell	4,899.55	213.19				9.00						5,121.74	1,066.70	6,188.44
State	1,374.80	332.34	25.87		31.75		2,791.40	1,817.02	3,801.62			10,174.80	24.47	10,199.27
North Carolina	3,071.91	93.30						106.25				3,271.46	391.47	3,662.93
Ohio	7,305.99	405.30						1,710.71	578.00			10,000.00		10,000.00
Oregon	1,811.65	188.35						2.13				2,002.13		2,002.13
Puerto Rico	4,828.03	499.28	267.73				8.00	699.67	211.50			6,514.21	4,927.00	11,441.21
Tennessee	5,840.47	387.25		270.69		25.00	1.99	3,667.45				10,192.85	147.50	10,340.35
Texas	12,549.57	1,807.68	16.53	79.69			1,394.21	153.84				16,001.52	4,471.13	20,472.65
Washington	5,286.65	872.56		.20		85.41						6,244.82	1,342.31	7,587.13
West Virginia	1,800.00											1,800.00		1,800.00
Wisconsin	5,668.39	646.92	21.69	2.70	419.12		620.70	906.84	373.99			8,660.35	7,028.31	15,688.66
Total	215,876.46	13,184.72	609.78	1,227.33	1,620.47	4,095.54	8,908.32	25,656.58	20,621.48		103.59	291,904.27	50,354.93	342,259.20

[1] Include allotments from the appropriation for fiscal year 1952 plus unexpended balances of allotments from appropriation for fiscal year 1951.

SUBJECT INDEX

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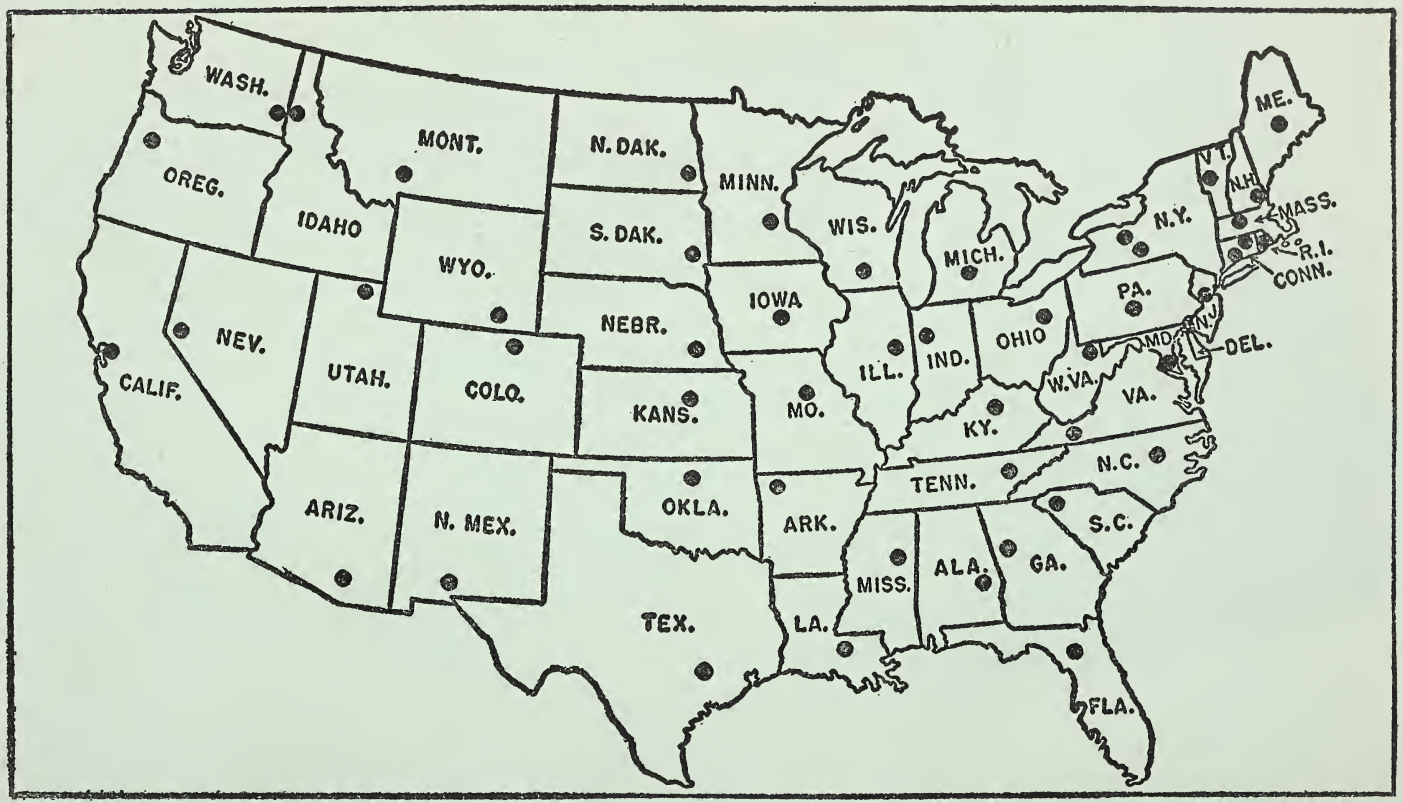
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS